SCRAP TIRE MANAGEMENT IN ONTARIO

JANUARY 1991

Ontario
Environment
Environnement

ISBN 0-7729-7830-1

SCRAP TIRE MANAGEMENT IN ONTARIO

Report Prepared By:

Waste Management Branch
Ontario Ministry of the Environment

First Printed January 1991
Second Printing June 1991
Third Printing February 1992

PRINTED ON RECYCLED PAPER
IMPRIMÉ SUR DU PAPIER RECYCLÉ

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SCRAP TIRE MANAGEMENT IN ONTARIO

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PREFACE

This study of scrap tire management in Ontario was sponsored by the Ontario Ministry of the Environment (OMOE). While the study was under way the study team met, on a monthly basis with the Task Force for Scrap Tire Disposal to review progress and to discuss the work that was scheduled for the next month. Task force members are drawn from the tire manufacturing industry, tire dealers, the OMOE, municipalities, and the environmental movement. The Task force provided the study team with invaluable insights into scrap tire management practices in Ontario and helped to identify the key stakeholders in the management of Ontario's scrap tires. The contribution of the members of the task force is gratefully acknowledged.

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GLOSSARY

Asphalt Concrete -	A highway paving material consisting of a mixture of asphalt binders and solid aggregate particles.
Asphalt Rubber -	A mixture of asphalt and ground vulcanized rubber used in highway construction or maintenance applications.
Buffings/Buffing Dust -	Vulcanized rubber abraded from a tire tread in preparation for retreading.
Carbon Black -	Fine particles produced by thermal decomposition of carbon materials such as hydrocarbons or wood.
Char -	A solid residue from pyrolysis containing carbon black, and incombustible components present in tires.
Chip Seal -	A thin layer of sprayed asphalt (sometimes rubberized) and subsequent aggregate placement used to prolong pavement surface life.
Crumb Rubber -	Fine vulcanized rubber particles resulting from mechanical or cryogenic size reduction processing of scrap tires or other rubber products.
Cryogenic -	Use of low temperature exposure to alter physical properties of a material. Cryogenic processing of rubber decreases its natural resiliency, allowing it to be shattered like glass upon impact.
Fatigue Cracking -	Cracks in a highway surface (generally within the wheel paths) resulting from repeated compression by vehicle weight.
Mesh -	A size definition describing the number of openings per inch, i.e., a 50 mesh screen has 50 openings per lineal inch or 19.7 openings per centimeter.
Pyrolysis -	Thermal decomposition of tires in an oxygen-limited environment to yield gas, oil, and char products.
Reclaim -	Product resulting from rubber reclamation.

Reflective Cracking - Cracks in a highway surface resulting from transmission of existing cracks in a subsurface layer to the surface layer.

Rubber Reclamation - Degradation of the rubber structure through use of mechanical, thermal, or chemical processes.

Stress Absorbing Membrane (SAM) - A rubberized asphalt layer applied over existing pavement to retard fatigue cracking.

Stress Absorbing Membrane Interlayer (SAMI) - A rubberized asphalt layer applied over an existing surface before application of a surface asphalt concrete to retard reflective cracking.

Supplemental Fuel - A combustible material which displaces a small portion (typically less than 25%) of traditional fossil fuel usage.

Tire-Derived Fuel - A uniformly shredded product produced from whole scrap tires for use as a fuel.

Vulcanized Rubber - Rubber which has been chemically reacted with sulphur and accelerators under suitable conditions to achieve modified physical properties over a wide temperature range. Examples of such properties include decreased plastic flow, less surface tackiness, increased elasticity, increased tensile strength, and lower solubility.

EXECUTIVE SUMMARY

Introduction

Every year seven to eight million scrap passenger car and truck tires are generated in Ontario. More than 60 percent of these scrap tires currently end up in landfills, and an additional 10 percent in "tire piles". Fewer than 700,000 tires each year are recycled by processing them into raw materials for other products. The objective of this study is to identify policy options that will promote the "Three R's"--reduction, re-use and recycling--as they apply to scrap tire management.

The topics covered in the report are: current scrap tire management practices in Ontario, processing technologies to recycle tires into other products, scrap tire management programs and practices in other jurisdictions, and an analysis of policy options to achieve the objective.

Current Scrap Tire Management Practices

Scrap Tire Generation

The generation rate of scrap tires is proportional to automobile registration. The percentage of new tire sales in each of the six Ontario Ministry of the Environment (OMOE) regions closely matches regional registration statistics and the assumption of this relationship for used and retread tire sales produces provincial totals that agree well with tire demand.

The Southeast, West Central, and Central Regions show the highest rates of passenger scrap tire generation, from all sources, in Ontario. The distribution of scrap tire generation varies from motor vehicle registration by less than 2 percent per region when other tire types are included. The peripheral regions (South East, South West, North East and North West) represent a slightly higher percentage of the total when heavy vehicle tires are included.

However, 48 percent of all tires are still sold in the Central Region (where 48 percent of all vehicles are registered). The shift to a higher volume of heavy vehicle tire sales per dealership in the more rural regions was also noted in the tire dealer survey.

In all of the southern regions, passenger tires represent over 80 percent of sales by volume, with a high of 92 percent in the West Central Region. The portion for the northern regions is closer to 70 percent. The value changes significantly when passenger tire equivalents are considered. In southern regions, passenger tires represent about 60 percent of sales by weight (except for West Central where the 1989 value is closer to 75 percent): in the northern regions, passenger tires represent less than half of the total weight of all tires sold.

These ratios seem to indicate that the sale of heavy vehicle tires in peripheral regions may skew Ontario's overall generation of tires by passenger tire equivalent. However, due to the sheer volume of units sold in the central regions, the breakdown for Ontario is about 86 percent sales by volume and 62 percent by weight (almost exactly that of Central Region).

Management Costs

The average scrap tire management cost, in dollars per passenger car tire in each of the regions are: Southwest - $0.69, West Central - $0.71, Central - $1.27, Southeast - $0.80, Northeast - $0.34, Northwest - $0.18. Clearly Central Region, generating the largest number of scrap tires, also pays the highest cost per tire for handling, with other southern regions close behind. The availability of landfill sites that do not charge tipping fees in both northern districts accounts for the relatively low costs faced by dealers there.

Retreading

Very few passenger tires are retreaded in Ontario. Although some retread of light vehicle tires is known to occur (mostly of light truck tire casings), most dealers interviewed do not sell *any* retreaded light vehicle tires. Consequently, the provincial average for the light vehicle retreading rate is assumed to be zero.

Conversely, a high percentage of heavy vehicle sales are retreads. The average obtained from the survey is nearly sixty percent. (The calculations indicate that retreads amount to about 14 percent of total shipments by weight.)

Dealers indicated aesthetic as well as economic barriers to higher retread sales in the passenger tire market. Those that do retread however, indicated that dealers obtain high margins on retread sales, and that more retreads could be sold if marketing efforts were increased. Most consumers view the price difference between retreaded tires and new tires as not worth the perceived loss in safety.

The initial cost of new heavy truck tires, and the aggressive refund schedule (most dealers give between $80 and $100 for a good heavy truck tire casing) contribute to the high retread rates for heavy truck tires. Some dealers noted that commercial tire retreading is slowing due to owner's tendencies to prolong tire life, which renders fewer casings suitable for retreading.

Resale

Between 10 and 30 percent of used passenger tires are resold (the overall Ontario average is about 14 percent). Used tires face the same sort of aesthetic barriers as retreads, but have a distinct economic advantage: the cost of additional processing is not required. Used tires are usually only about one-quarter the price of new ones. Still, it is unlikely that this percentage will rise much.

Resold and retreaded tires do not directly reduce the quantity of tires disposed since the tire replaced by the retreaded/reused tire must in turn be disposed of. Instead, these intermediate destinations reduce the demand for *new* tires, and hence, do result in an overall reduction of tire disposal requirements.

Recycling

Economics is one of the major barriers to recycling tires. The costs of disposal to tire dealers establish a ceiling on what recyclers can charge scrap tire generators. Since tire dealers directly handle about three-fourths of scrap tires (by weight), recyclers must charge less per tire than disposal costs or recycling will not become a significant factor in scrap tire management. The problem is exacerbated in regions with very low scrap tire disposal costs.

Effect of the Tyre King tire fire on disposal options and costs

Most operators of tire piles have stopped accepting scrap tires since the fire at the Tyre King site in Wapole Township near Hagersville, Ontario in the winter of 1990. The pile contained approximately 13 million scrap tires. The cost of complying with the imposition and enforcement of fire safety regulations has made the business of accumulating tires no longer economic for most stockpilers.

Since the fire, the charge to dispose of a tire with a stockpiler has increased dramatically. Whereas the charge to accept a passenger tire was generally $1.00 before the fire, tire dealers have reported quotes from stockpilers of up to $10.00 per tire to dispose of their scrap tires since the fire.

Tire jockeys report a significant increase in business since the fire, since they often provide the only legal option to dispose of tires. However, the sudden halt in stockpilers accumulations since the fire, and the frequent increases in tipping fees, has resulted in a dramatic rise in operating costs for tire jockeys.

Effect of increased tipping fee on the legal disposal for scrap tires

The Keele Valley landfill servicing Metro Toronto has been recording the number of tires it has disposed of since 1987. In 1987, when the tipping fee was $18 per tonne, an average of 413 tonnes of tires were received per month at the landfill. The number of tires disposed of at the landfill significantly decreased only when the tipping fee rose to $85 per tonne in 1989. After the Hagersville fire the number of tires arriving at Keele Valley increased sharply again, averaging about 400 tonnes per month, almost identical to the number of tonnes being received before the tipping fee increases.

Evaluation of Processing Technologies

With the introduction of Ontario's tax of $5.00 per tire on new tires sold since June 1, 1989 and the subsequent announcement that $16 million has been allocated for tire recycling projects there has been no shortage of proponents coming forward with proposals to solve Ontario's scrap tire management problem. During the course of the study virtually all of the proponents were interviewed. From the information obtained about the main proponent's proposed projects, it is clear that they are very optimistic about their ability to process all of Ontario's scrap tires and then some. However, it must be noted that virtually all of the proponent's proposals are predicated on the availability of significant amounts of financial support, from the government of Ontario, for the capital cost for processing facilities and product and market development.

It is necessary to put the costs to develop the various processes, and their probability of success, in terms of the number of scrap tires they are likely to absorb, into perspective before policy options can be evaluated. The costs and prospects for scrap tire processing technologies are as follows.

Crumb Rubber in Consumer and Industrial Products

Crumb rubber processors can operate profitably at a tipping fee of $0.65 to 0.75 per scrap passenger tire received at their door. With landfill tipping fees in Ontario's major metropolitan areas ranging from $0.83 to 1.36 per passenger tire there would appear to be adequate financial incentives for crumb rubber processors to establish facilities. However, the major barrier to increasing usage of crumb rubber in products is the size of the market for such products. Simply stated, there are 200 to 250 million scrap tires generated annually in North America chasing consumer and industrial product markets that at best will be capable of absorbing less than 10 percent of them. Recycling is the first choice for virtually all of the North American jurisdictions which have scrap tire management programs.

Based upon proposals submitted to OMOE, it would require public subsidies of about $6 million for the product and market development and $25 to 30 million in financial incentives to establish the processing and manufacturing facilities needed to aggressively pursue world markets for consumer and industrial products containing recycled tire rubber. This magnitude of expenditure would likely create sufficient processing capacity in Ontario to turn all of Ontario's scrap tires into crumb rubber. However, while there is considerable potential to displace crumb rubber that is currently imported from the United States and other waste rubber materials in existing products, there would be no assurance that world markets would expand fast enough or that Ontario producers would capture large enough shares of those markets to absorb the rest of the crumb rubber that could be produced in Ontario.

Rubberized Asphalt

If rubberized asphalt was used throughout Ontario, this application could absorb all of the scrap tires generated in Ontario. However, various proponents have been trying, for more than 20 years, to demonstrate the economic benefits of rubberized asphalt without notable success. Unless economic benefits can be demonstrated the additional cost of using rubberized asphalt will be about $2.00 per passenger tire equivalent on an ongoing basis. Given the rapid increase in the cost of alternative forms of scrap tire management, rubberized asphalt could become a very attractive option if the Ministry of Transportation's (MTO) test program shows that there are no other disadvantages of using rubberized asphalt other than its cost.

Recovery of Raw Materials

Recovery of raw materials is also an application which could potentially absorb all of Ontario's scrap tires, but significant technical and economic hurdles must be overcome before recovery of raw materials from scrap radial tires becomes feasible. Reclaimed rubber cannot be used in new tires without unacceptable negative effects on tire safety and life. Pyrolysis can convert tires into oil, gas, and char. The oil and gas can be sold, but markets for the char have not been found. Without markets for the char, recovering the fuel value of tires through pyrolysis is not economically attractive.

Tire Derived Fuel

Tire derived fuel (TDF) has the distinction of being the only application that is technically feasible, economically attractive without subsidies, and capable of absorbing all of Ontario's scrap tires in the short term. TDF's major shortcoming is that it is not high on the management hierarchy.

Future Prospects

A high percentage of the proponents of the various scrap tire processing technologies were either promoting concepts or start-up operations. While it is encouraging to see that the entrepreneurial spirit is alive and well in Ontario, these proponents face a very difficult task. Concepts and start-ups in general and those involving scrap tire recycling in particular have very low success rates, perhaps one in 10.

There are a number of Ontario rubber and plastics products manufacturers that have the research and development, manufacturing, and marketing capabilities needed to develop the products and markets necessary to increase the number of scrap tires that are used in consumer and industrial products. Many of these companies have yet to show an active interest in scrap tire recycling. The probability of OMOE achieving its scrap tire recycling objectives would be much improved if it actively sought out such firms and encouraged them to take advantage of the programs that OMOE offers to promote scrap tire recycling.

Scrap Tire Management Programs in Other Jurisdictions

Comprehensive scrap tire management programs are either non-existent or in the early stages of development in most countries. A review of scrap tire management practices in European countries revealed a number of scrap tire applications, but a general absence of comprehensive national scrap tire management programs. Extensive use is made of scrap tires as a cement kiln fuel in Germany, Switzerland, Austria, Denmark, the United Kingdom, and Japan with some usage in Greece, Spain, and Mexico. Dedicated whole tire combustion units exist in Germany, Italy and the United States, with a new, larger facility currently in the final development stages in England. Small crumb rubber production facilities exist in the Netherlands, France, Germany, Sweden, Japan, and the United States.

A number of U.S. states have initiated scrap tire management programs, and their experience may offer some guidance for jurisdictions that are in the process of developing scrap tire management programs.

Various funding mechanisms have been utilized to generate revenue required for establishing and maintaining tire management programs. Although vehicle registration fee increases offer the advantage of optimum collection efficiency, a fee based upon sale of new tires is a feasible alternative when there is a pre-existing sales tax collection and enforcement mechanism in place. Ontario's tire tax is considerably higher than similar levies in U.S. states, but it provides resources for development and support of a sound program.

One major objective of tire programs is generally prevention of uncontrolled tire stockpiles that become public liabilities. Requiring registration of haulers, processors, and all disposal sites provides a mechanism for scrap tire control. Control is enhanced by requiring records to be maintained, manifests, and/or performance bonds to ensure regulatory compliance. Regulating stockpile size, site conditions, and bonding requirements have proven to be additional desirable measures which decrease the economic advantage of stockpiling while controlling potential public liability.

The most effective programs have provided and encouraged a variety of tire management alternatives. Elimination of landfilling prior to the creation of other alternatives has enhanced development of alternatives, but led to massive stockpiling (and potential liability) in the interim period as processing facilities are being developed. Requiring shredding prior to landfilling reduces volume, while the resulting increased disposal cost encourages other management methods. Effective programs have recognized the product markets as a key to the tire management solution and have encouraged their development through research and/or market support initiatives. Successful programs include a variety of market uses for scrap tires including materials recovery, energy, and use in various structures. Higher value uses can be encouraged with tiered market support initiatives if inherent, market incentives prove to be inadequate.

Policy Analysis

The OMOE faces three major policy challenges. The first is to decrease scrap tire generation and promote the diversion of scrap tires from disposal to productive use.

The second policy challenge is to determine under what conditions scrap tire piles should be permitted to accumulate. In the short term recycling can absorb only a fraction of the scrap tires that are generated in Ontario. The remainder must either be disposed of or stored in anticipation of new markets being developed for products containing recycled tire materials.

The third policy challenge is to create environmentally-acceptable destinations for scrap tires. In the aftermath of the Hagersville tire fire and the Ontario Government's response to it, the scrap tire collection network has ceased to function in a number of areas of the province due to the closure of many of the sites that previously accepted scrap tires.

An adequate supply of scrap tires at a suitable price is essential for their productive use. Recycling and energy recovery requires a payment to the processor of $0.50 to $3.00 per scrap tire for these management options to be economically feasible. Cheap disposal in landfills in the past has played a major role in diverting scrap tires from productive use to disposal. The current trend to rapidly increasing landfill disposal costs provides the clearest and most powerful incentive to find other management options for scrap tires.

Policies that would discourage scrap tire disposal and encourage productive use are: require shredding prior to landfilling, which will raise the cost of disposal by about $0.50 per tire; increase monitoring and enforcement to cut down on illegal disposal and prevent shipment to jurisdictions with low landfill tipping fees; require manifesting of all scrap tire flows which would provide a basis for monitoring and enforcement; provide economic incentives for recycling scrap tires through direct payments to processors; funding of product and market development; and government procurement policies that favour goods containing recycled materials.

Although the OMOE has implemented a scrap tire management program that contains elements of most of the policy options outlined in the previous paragraph, some fundamental problems remain. Tire dealers and other scrap tire generators are finding it increasingly difficult to find legal destinations, at a reasonable price, for their scrap tires. In many areas of Ontario, consumers are being charged a scrap tire disposal fee, typically of $1.00 to $2.00 per tire, in addition to the tire tax, by tire dealers, when they buy new tires. This would indicate that there is not yet an efficient mechanism for channelling the revenues from the tire tax into programs that effectively deal with the high cost of scrap tire management. The high cost of disposing of tires in landfills (currently $1.35 per scrap tire in the Greater Toronto Area and rising rapidly) provides an adequate financial incentive to make a number of tire recycling options economically feasible. The barrier to more recycling of scrap tires is a lack of markets for products using materials derived from scrap tires.

If OMOE wishes to influence the destination of scrap tires it must be aggressive and pro-active in creating destinations of choice for scrap tires. This will likely require the use of differential subsidies that favour productive uses of tires over disposal. Subsidies should only be paid to site operators who have a credible plan for long term management of the scrap tires. In order to eliminate the need for tire dealers to charge customers a scrap tire disposal fee the least preferred, but acceptable, tire management option (likely a well-managed pile) would have to be available at zero cost to scrap tire generators. Subsidies to scrap tire processors that recycle tires or recover some of their value would have to be high enough for the processors to pay generators a fee for their scrap tires, in order to ensure a reliable flow of scrap tires to the processors. The more-favoured the scrap tire management option, the higher the subsidy and, therefore, the fee that could be paid to scrap tire generators.

If not enough commercially-operated destinations for scrap tires can be developed, municipalities could be provided with the funds necessary to cover the costs of safely stockpiling scrap tires at municipal landfills and periodically disposing of them in the best way available at the time. In order to ensure that the tires are disposed of in an orderly fashion, the municipalities that control the tire piles could be required to issue a tender for disposal of the tires whenever a pre-determined number of tires had accumulated.

The lack of markets for products containing materials derived from scrap tires precludes a short-term recycling solution to the scrap tire problem. While a longer term recycling solution is possible, it is by no means certain. Therefore, the OMOE has the choice of encouraging less-favoured management options such as TDF and shredding and landfilling or accepting the costs and risks of storing whole tires or tire shreds for a number of years in anticipation of markets for recycled products that may never develop.

Since the major barrier to recycling of scrap tires is a lack of markets, any direct subsidies to scrap tire processors, beyond the ones described above to channel scrap tires to more-favoured uses, should be restricted to funding product and market development efforts. Differential subsidies, as discussed above, that are based on the number of tires that are received and processed should be adequate to encourage the development of sufficient processing capacity to serve the markets for products containing recycled tire materials as those markets develop.

1. INTRODUCTION

A. Background

Every year seven to eight million scrap passenger car and truck tires are generated in Ontario. More than 60 percent of these scrap tires currently end up in landfills, and an additional 10 percent in "tire piles". Fewer than 700,000 tires each year are recycled by processing them into raw materials for other products. While it is technically possible to retread a fairly high percentage of passenger tire casings, virtually none of the passenger car tires sold in Ontario are retreaded. Most heavy truck tires are retreaded several times, but as with all retreaded tires, heavy truck tire casings eventually become unsuitable for retreading, and end up in the disposal stream.

Landfilling of whole tires has never been a good disposal option. Because tires are resistant to compaction they take up a disproportionate amount of space when they are buried in landfills. In some landfills, methane gas, given off by decaying wastes, collects in the cavities of tires which cause them to "float" to the surface. While landfilling whole tires is a poor disposal method, its popularity has been largely due to a lack of feasible alternatives. The growing shortage of landfill capacity, especially in densely-populated areas where the majority of scrap tires originate, and the trend to minimize landfilling of wastes that potentially can be reused or recycled has changed landfilling of whole tires from a poor option to an unacceptable one.

The next most popular method of scrap tire management, storing them in piles, in anticipation that markets will develop for them, recognizes the potential value of scrap tires as a resource, but tire piles present a number of problems. Markets for materials and products derived from scrap tires have been very slow to develop. As a result tire piles are often the final destination for scrap tires. Apart from being unsightly, tire piles are breeding grounds for insects and vermin. And, as the tire fire near Hagersville demonstrated, tire piles present a serious fire hazard.[1]

B. Initiatives to deal with the scrap tire problem

Recognizing that current scrap tire management practices are not environmentally acceptable, the Ontario Ministry of the Environment (OMOE) has taken a number of initiatives to deal with the scrap tire problem. In 1989 the OMOE and the Ministry of Treasury and Economics introduced a $5.40 ($5.00 plus 8 percent Provincial Sales Tax) per tire tax on new tires sold in Ontario. Tire retailers have been collecting the tire tax since June 1, 1989. For the fiscal year beginning April 1, 1990 $16 million from the tire tax revenues has been allocated to programs to remediate tire piles and promote recycling of scrap tires. The money is being used primarily to fund OMOE programs to support product and market development for products using materials derived from scrap tires and for the establishment of scrap tire processing facilities. The level of funding for scrap tire management programs will be determined on an annual basis.

The Ontario Scrap Tire Task Force was formed by the OMOE in November, 1989, in response to initiatives from the Rubber Association of Canada and the Ontario Tire Dealers Association. The task force members are drawn from the tire manufacturing industry, tire dealers, the OMOE, municipalities, and the environmental movement. The overall objective of the Task Force is to support the development of an effective scrap tire management program in Ontario.

In April, 1990 Regulation 309 under The Environmental Protection Act was revised to give the OMOE additional authority to regulate tire piles and scrap tire processing facilities. The revisions classified used tires as "designated wastes" and used tire sites as "waste disposal sites". The effect of the revision is that after October 1, 1990 all sites on which there are 5,000 or more used tires or tire units will require a Certificate of Approval, issued by the OMOE, in order to remain in operation. By attaching conditions to the Certificate of Approval that may include: the number of tires that can be stored at any time, fire prevention measures, financial guarantees, limitations on the processing and/or disposal methods that are acceptable and others, the OMOE will have the same control over disposal of used tires as it does over disposal of other designated wastes.

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[1] Approximately one week after this study started a tire pile managed by Tyre King in the outskirts of Hagersville, Ontario, containing an estimated 13 million tires, was apparently set alight by vandals. Although the long term environmental impact of the fire, which burned for 17 days, is not yet known it has been described as one of "the most severe environmental episodes in North America".

C. Objectives of this Study

The objective of this study is to identify policy options that will promote the "Three R's" -- reduction, re-use and recycling -- as they apply to scrap tire management. As with other waste management programs that are based on the Three R's, the waste management plan for scrap tires will likely consist of a number of management methods that can be ranked in terms of their impact on the environment.

Since the markets for the products that result from the most environmentally acceptable methods of scrap tire disposal that are identified are unlikely to be large enough to absorb all of Ontario's scrap tires, at least in the short term, it is necessary to define a scrap tire management hierarchy. The objective of the study then becomes to identify and evaluate public policy options that will direct as many scrap tires that are suitable or that the market can absorb, depending on which condition is met first, into the management option at the top of the hierarchy; as many as possible of the remainder into the second option; and so on until substantially all of the scrap tires are managed in an environmentally acceptable manner.

The hierarchy that will be used in this study, starting with the most environmentally acceptable management option and ending with the least acceptable option is as follows:

- Reduction - The scrap tire generation rate can be reduced by technological developments that improve the service life of tires and by programs that encourage motorists to drive less.
- Re-use as Tires - Scrap tires that are serviceable can be sold in used tire markets and suitable scrap tires can be processed as casings for retreading. Both re-uses will extend the length of time before the tires enter the waste stream.
- Recycle Into Other Products - This can take two forms: by cutting scrap tires into suitable shapes and assembling them into new products (for example: blasting mats, floor mats, muffler hangers, etc.) or by grinding the tires into crumb, and using the crumb in asphalt mix or rubber/plastic compounds for a wide variety of moulded or die cut products. Using the latter method it is theoretically possible to use the rubber and some of the other materials in scrap tires over and over again.
- Re-use of Whole Tires in Civil Engineering Projects - Examples of this application are artificial reefs, erosion control and stabilizing mine tailing ponds.
- Tire Chips in Civil Engineering Projects - Examples of this application are road beds, the core of earthen embankments, septic tank drainage fields, and as a compost bulking agent.

- Recover The Raw Materials in Tires - The raw materials used to manufacture tires are primarily, natural rubber, synthetic rubber (which is processed from petroleum), carbon black, fabric and steel wire. Those raw materials which can be recovered can be used to make new products.

- Process Into Tire-Derived Fuel - Burning tires limits them to a single end use, but it does have the advantage of recovering their fuel value and prevents them from being dumped in landfills and elsewhere.

- Shred and Landfill in Monofills - This would eliminate many of the problems of landfilling tires with municipal solid wastes. If at some future time the tire chips become a valuable resource, the monofill can be "mined".

Extending the service life of tires was placed at the top of the hierarchy since it is the obvious first step in resource conservation and reducing the scrap tire generation rate. Growth in the use of radial tires since 1970 has contributed significantly to the reduction in the number of scrap tires that are generated. The service life of radial tires is about three times as long as bias ply tires. However, since radial tires currently account for more than 90 percent of all new tires sold, there is not much potential remaining to reduce the number of scrap tires that are generated by increasing the use of radial tires.

Programs that encourage motorists to drive less have some interesting possibilities not only for reducing the number of scrap tires that are generated, but also for fuel conservation and reducing the amount of emissions that contribute to global warming and air pollution. However, an examination of such programs is beyond the scope of this study.

Recycling into other products was ranked at the top of the scrap tire management options in the hierarchy because it offers the possibility of numerous uses of the tire materials.

The next two options, use of whole tires and tire chips, respectively, in civil engineering projects generally do not offer the opportunity for more than one use of the scrap tire materials, but the tires are virtually removed from further management considerations.

The main output of processes to recover the raw materials in tires, *for which markets are available*, is a form of crude oil. Since 90 percent of crude oil is processed into fuels, until such time as other materials, such as carbon black, can be recovered from scrap tires this option is effectively equivalent to recovering the fuel value of tires.

By processing scrap tires into tire-derived fuel, their fuel value and some of the steel used in their construction can be recovered. However, this alternative does not offer the possibility of using most of the tire materials more than once, and is, therefore, placed lower on the hierarchy than recovery of raw materials.

Shredding scrap tires and storing the chips above ground, in anticipation of future uses, was not included in the hierarchy since one of the goals of this study is to get rid of tire piles. In addition, there is the very real possibility that the tire chips would have to be stored virtually indefinitely. With the growing number of jurisdictions in Canada and the United States that are actively promoting tire recycling and the limited world markets for products containing recycled tires, a glut of tire chips would likely quickly develop which would not begin to clear unless and until the usage rate exceeded the generation rate of tire chips. In short it would be the tire pile problem in a slightly different form.

D. Contents of the Report

The next chapter of the report documents current scrap tire management practices in Ontario. It is based on a number of surveys of the various stakeholders in scrap tire management. The survey data were used to estimate the number and type of scrap tires generated, determine the collection and disposal costs, identify disposal streams and estimate the number of scrap tires that enter each disposal stream for each of the six OMOE regions in Ontario. In addition, the location of tire piles are documented along with the estimated number of tires in each pile and other details.

Chapter three contains a description and evaluation of processing technologies to recycle tires into other products. The evaluation focuses on the technical and economic feasibility of each processing technology.

In Chapter four scrap tire management programs and practices in the United States, Europe, and Japan are described. The strengths and weaknesses of the programs that have been in existence long enough to permit a brief evaluation are discussed.

The final chapter, Chapter 5, contains the policy analysis. The goal of the policy analysis is to identify and evaluate of a number of options that will result in changes to the baseline scrap tire management practices that were described in Chapter 2. These options will consist primarily of various incentives to make promising recycling technologies identified in Chapter 3 technically feasible and economically attractive, and thus promote greater usage of them.

II. CURRENT SCRAP TIRE MANAGEMENT PRACTICES

This chapter provides a description of the numbers and flows of scrap tires in Ontario and the costs associated with each of the disposal options for 1989. Data for the baseline scenario were derived from surveys with tire dealers, owners of stockpiles, tire jockeys, landfill operators and Ontario tire manufacturers. The first section describes the objectives, methodology and qualifications for each of the surveys; the second section describes the results of the survey; the final section describes the regional variation in scrap tire flows, and includes a discussion on the barriers to reuse and recycling of scrap tires as well as a description of the effect of the Hagersville tire fire on management practices in Ontario.

Survey questionnaires were used in all of the surveys to guide the interviews, and the results were tabulated on electronic spreadsheets for analysis.

A. Stakeholder surveys

1. Ontario Tire Dealer Survey Summary

Objective

About three-quarters of all scrap tires in Ontario are generated by tire dealers. As major players in the new and scrap tire businesses, tire dealers play a significant role in the handling of scrap tires. The following information was sought from Ontario tire dealers:

i) the tire generation rates by tire type;
ii) a description of scrap tire disposal methods;
iii) the cost to dealers of tire disposal;

iv) retread/reuse/recycle characteristics, economics, and barriers; and
v) dealer attitudes and opinions on scrap tire management.

Methodology

Fifty Ontario tire dealers were contacted over the course of several weeks. Most of the tire dealers that were included in the survey were drawn from a list provided by the Ontario Tire Dealers Association (OTDA). Seven-to-ten dealers in each of the Ontario Ministry of the Environment (OMOE) geographic regions were randomly selected from the OTDA list. In regions where the OTDA list contained a small number of dealers, additional dealers were identified from the yellow pages of telephone directories.

In addition to segmenting the survey sample by region, efforts were made to include a mix of small as well as large dealers, those with access to retread facilities, franchise stores and independent stores.

Several of the larger dealers were interviewed in person, however the majority of the interviews were completed by telephone.

Qualifications

The Hagersville tire fire resulted in considerable changes in scrap tire management practices. Shortly after the fire many of the traditional scrap tire management options were no longer available to tire dealers. Tire dealers answers to some questions were often qualified as "pre-Hagersville" since, at the time of the survey, they did not know what their options were going to be.

Most dealers do not keep track of the volume of scrap tires that they generate. In almost all cases, the volume was calculated from other information. For example, most dealers knew the cost structure for tire disposal, and also how much they are charged in a given year. From this information scrap volumes may be calculated. Similarly, some dealers quoted scrap volumes as a percentage of sales (by tire type), and then provided sales estimates.

2. Landfill Survey Summary

Objective

Discussions with tire dealers, tire jockeys, recyclers, and manufacturers identified landfill sites as a large recipient of scrap tires. As a number of problems with landfilling whole tires are well known, and landfills in general are under increasing pressure to stop accepting tires, landfill operators were contacted with a view to garnering information on the current landfill practices in Ontario.

The survey was designed to gather the following information for a sample of Ontario landfills:

- i) the acceptability of tire disposal at Ontario landfills and historical problems associated with landfilling tires;
- ii) the major suppliers of tires to landfills;
- iii) yearly quantities accepted and landfilled or stockpiled;
- iv) site charges for tire disposal and the relationship to disposal of "regular" wastes;
- v) disposal methods employed by landfill operators with respect to tires; and
- vi) municipal bylaws and controls affecting landfill operators with respect to tires.

Methodology

A list of landfills known to have accepted tires was provided by the Ontario Ministry of the Environment. Conversations with dealers and stockpilers produced an additional number of known landfill sites. From this list approximately twenty landfill sites were selected and the operator contacted by telephone. An attempt was made to attain a geographically representative sample of landfill sites throughout Ontario.

Qualifications

Many landfill sites are in the process of changing or reviewing their scrap tire disposal practices. Landfill operators were probed to determine trends in future practices, but usually this information was speculative. Consequently, although the survey represents a baseline of Ontario landfill practices, the situation will very likely be different in the near future.

Although quantitative estimates were sought for many questions, most operators had only rough estimates for tire volumes handled at their site. Only one of the landfill operators interviewed currently tracks tire volumes.

3. Stockpiler Survey Summary

Objective

The stockpilers survey was designed to provide information on the following:

- i) the size and distribution of the piles in Ontario;

ii) the economics of tire piles in Ontario (how much are stockpilers charging to accept a tire; what are their options for disposing of tires and the cost of each option); and

iii) business-specific considerations are: Stockpiles accumulate on the properties of auto wreckers, tire dealers, recyclers, farmers, and junkyard owners. To some of these business types tires are a nuisance byproduct. To others they are a material resource and potential source of income. The objectives, concerns, sources of income and cost of disposal are identified for each business type.

Methodology

A list of stockpiles was obtained from the OMOE/Solicitor General survey. The survey included stockpilers and public landfills which had accumulated tires. Landfills were not included in this survey but were covered in the Landfill Survey.

Two criteria were used in the sample selection: size of the pile and the location. Owners of all piles containing more than 8000 tires were approached. The 5000 tire unit limitation for site approvals for tire stockpiles was developed after this survey was started.

It was anticipated that tire piles would be more or less evenly distributed throughout all the regions of Ontario. (Figure 1 shows a map of the OMOE regions.) However, in northern Ontario tires are deposited at landfills at a negligible tipping fee rendering privately owned stockpiles uneconomic in that region. Only one stockpile could be found in the Northwestern region. Tire piles in Northern Ontario which are located at landfill sites are covered in the survey of landfills.

Forty stockpilers were approached and all but three were willing to provide data. It was possible to obtain data from an external source for one of the three, and an estimate of the size of the stockpile for the remaining two were derived from the OMOE survey.

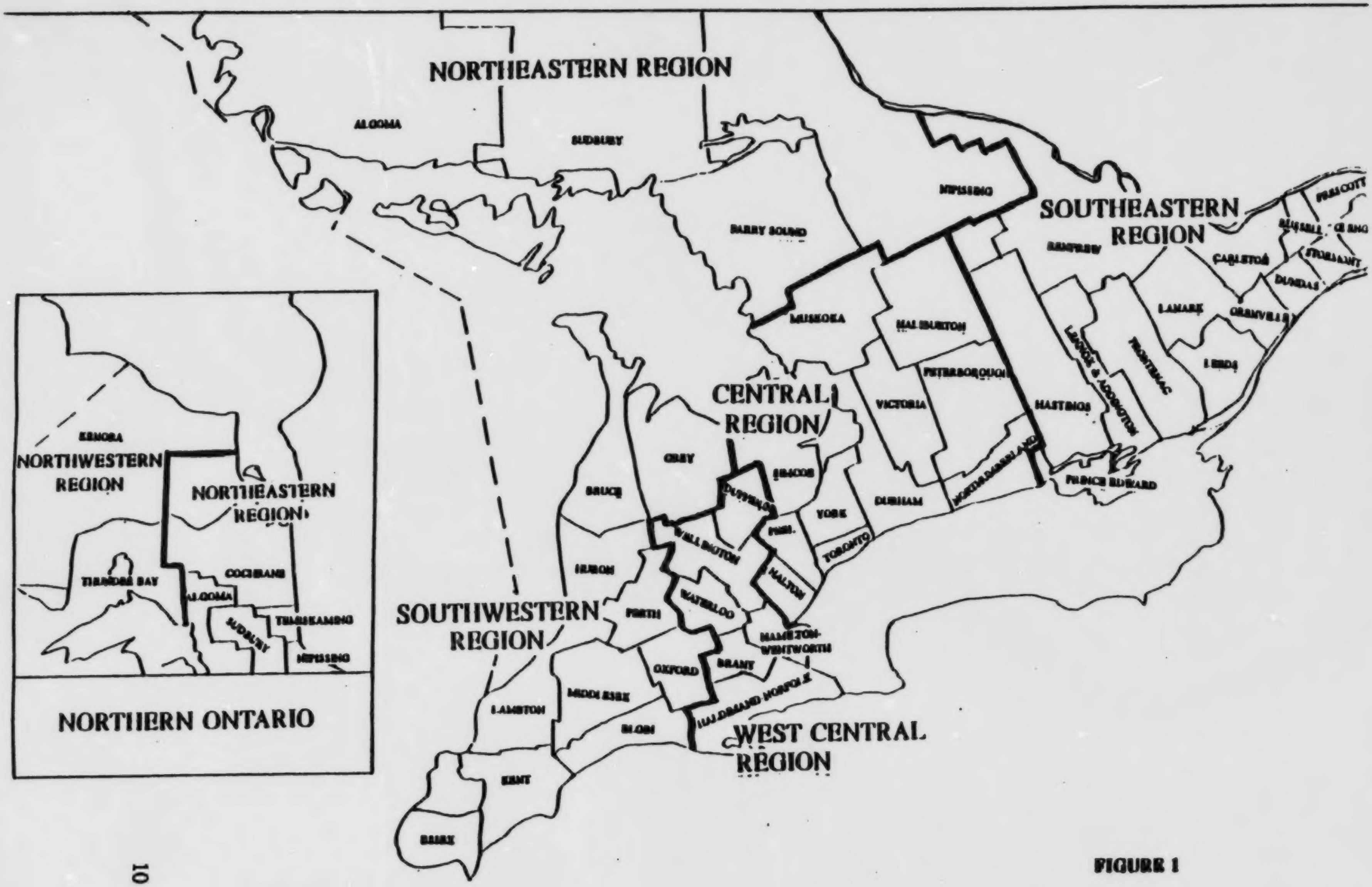

FIGURE 1

MINISTRY OF THE ENVIRONMENT—REGIONS

The breakdown of the sample is

auto wreckers	23
farmers	3
recyclers (operating)	3
recyclers (not operating)	4
tire jockeys	2
tire dealers	1
scrap tire piles	4

Although stockpilers in the last category may recycle or sell used tires, the volume of sales does not significantly reduce the pile. This group of stockpilers is referred to as 'Speculators' in the remainder of this summary.

Interviews were conducted either by telephone or in-person. In-person interviews were deemed necessary when the required data could not be obtained over the telephone.

Qualifications

The rate of scrap tire accumulation at tire piles represents the rate before the Hagersville fire. Since the fire most speculators have stopped accepting tires due to enforcement of fire safety regulations or control orders. Most auto wreckers continue to accept tires, although a few will only accept tires with the rims (this discourages dealers and increases used tire saleability).

4. Tire Jockey Survey Summary

Objective

The tire jockey/casing broker survey was designed to provide information on the following:

i) price per tire received;
ii) flow of tires to each management method;
iii) cost of each management method.

Methodology

Tire jockeys were identified by the OMOE, through the dealer and stockpiler surveys, and by other tire jockeys. Seven tire jockeys were surveyed. Of these, three operate out of the West-Central region and four out of the Central region.

Interviews were conducted either by telephone or in-person.

Qualifications

The data provided by three of the tire jockeys were of limited value: one tire jockey is stockpiling close to half of the incoming tires in anticipation of future markets; the second provided answers which could not be confirmed by dealers and recyclers; and the third tire jockey indicated that his operation was limited to selling and retreading used tires left at his dealership, and that he did not provide a collection service.

Four tire jockeys were able to account for the final destinations of all incoming tires and these numbers were confirmed by the dealers and recyclers with whom they deal. The data provided by those four tire jockeys show remarkably similar management allocations.

5. Tire Manufacturers' Survey

Objective

Tire manufacturers were approached for information concerning the generation of new tires. In particular, the following items were sought:

- i) regional sales figures by tire types;
- ii) manufacturing defect and warranty claim rates;
- iii) locations and costs of disposal sites for defective and warranted tires;
- iv) whether warrants of retreadability are provided by the manufacturers.

Methodology

The confidential nature of sales figures inhibited direct contact with individual manufacturers. Instead, Mr. Brian James of the Rubber Association of Canada approached the major manufacturers and posed the above questions. A summarized report was given to the study team showing the aggregated results.

The numerical and factual data has been incorporated in the following pages, with references made to the Rubber Association of Canada as appropriate.

B. Survey results

1. Tire Management Baseline

Description

Data from the surveys were used to develop a "baseline" for scrap tire management. The baseline contains estimates of tire flows, from generator to disposal, in 1989. It has the characteristic that the volume of tires flowing into Ontario every year (from manufacturers, auto wreckers, etc.) must ultimately be disposed: the number of scrap tires disposed must equal the number of scrap tires generated.

Tire sources, uses and disposal methods were all known prior to the survey. The survey data were used to allocate tire quantities to the various management pathways.

Survey Results and the Tire Management Baseline

The baseline shows the sources, intermediate handlers, and final destinations of tires in Ontario during 1989. Figures 2 and 3 depict this flow in passenger tires and *passenger tire equivalents*[2] for the province of Ontario (Appendix A presents similar diagrams showing the regional distribution of passenger tires and passenger tire equivalents).

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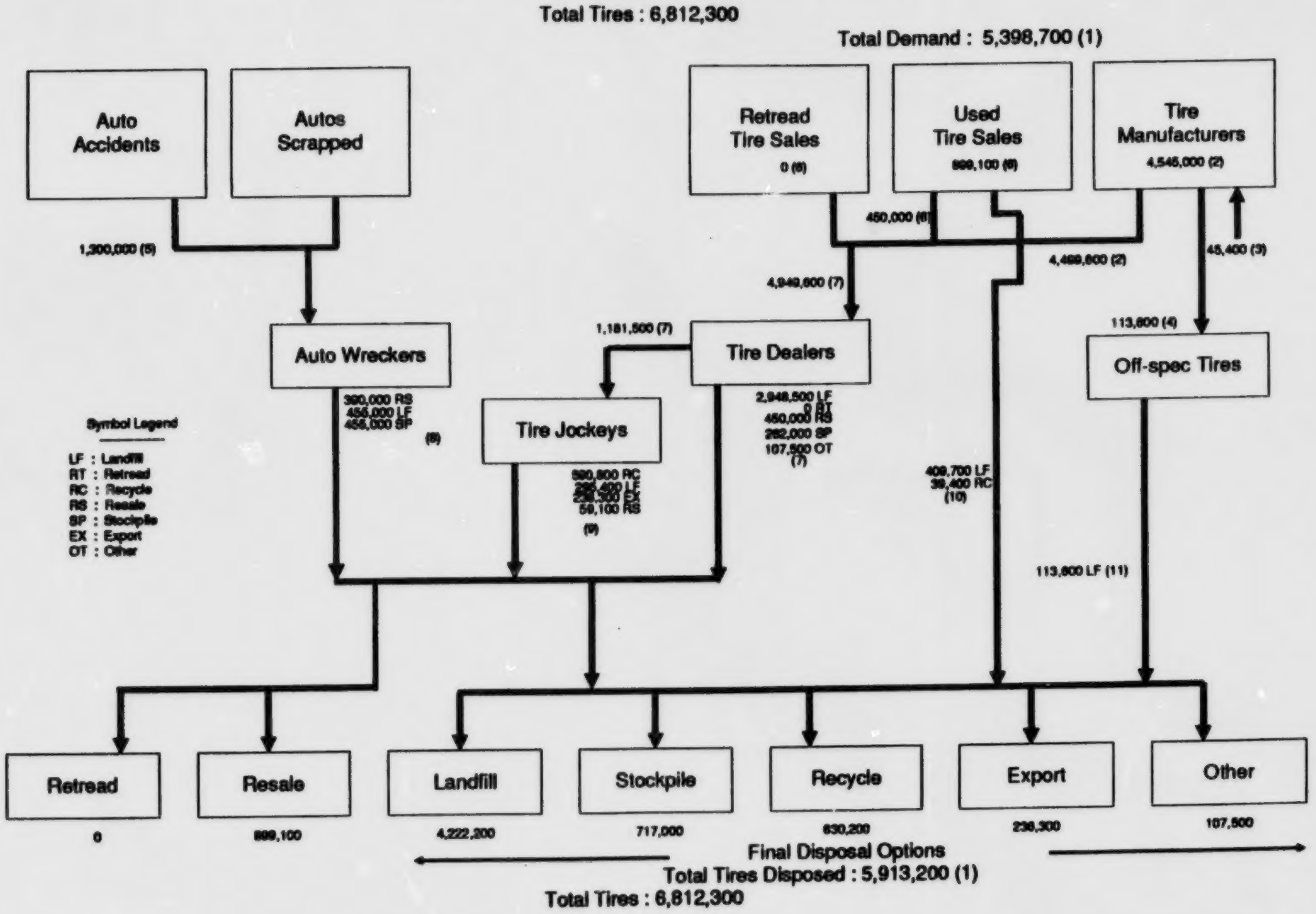
[2] A "passenger tire equivalent" of a tire type is defined as the number of passenger tires required to equal the weight of that tire type.

Figure 2

1989 Passenger Tire Flows in Ontario

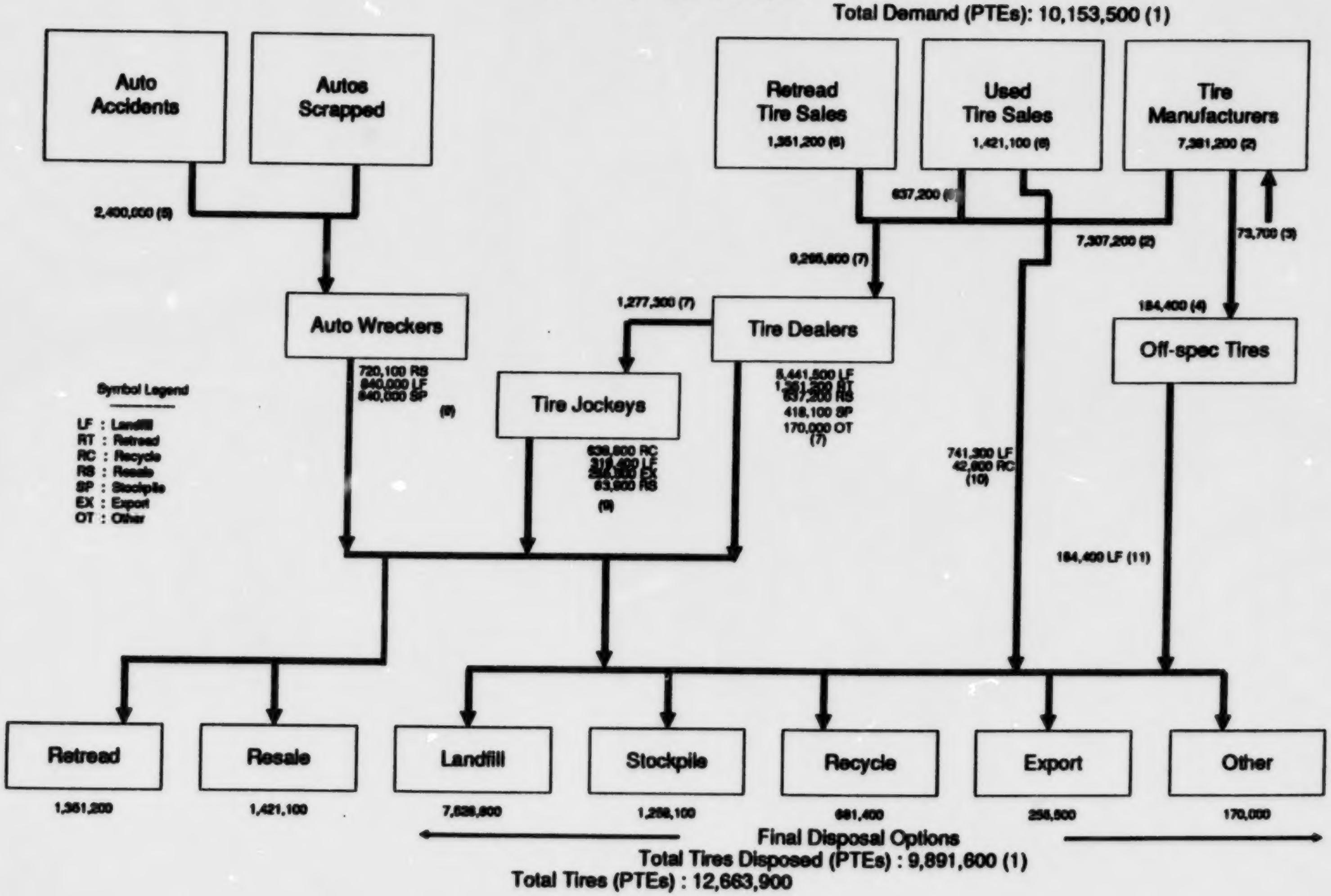


Numbers in () refer to notes following Figures 2 and 3

Figure 3

1989 Passenger Tire Equivalent Flows in Ontario

Total Tires (PTEs) : 12,663,900



Total Tires Disposed (PTEs) : 9,891,600 (1)

Total Tires (PTEs) : 12,663,900

Numbers in () refer to notes following Figures 2 and 3

Scrap Tire Flow Net Notes

1) All values are for 1989 quantities.
Total tire demand is calculated from retread, used and new tire *sales*: total tire disposal is the sum of all *final* disposal option quantities. Note that the number of tires entering the system (tire demand plus fleet scraps plus manufacturers' defects less warranty shipments) equals the number leaving (tires disposed plus retread and resale quantities).

2) Source: Rubber Association of Canada (R.A.C.), 08 May 1990, page 3 (personal communication):
The total number of tires shipped from manufacturers was cross-checked with published Statistics Canada figures for Canada. Regional quantities are prorated by Ontario automobile registration statistics, as published by Statistics Canada (auto registration weights are nearly identical to sales by region as reported by the manufacturers).

3) Conversations with tire distributors, manufacturers, and large dealers indicate that warranty replacements represent not more than 1 percent of sales. Since the shipment figures obtained from manufacturers were known to include warranty replacements subtracting 1 percent yields the net quantity shipped to dealers and avoids double-counting.

4) The defect rate of tire manufacturing plants in the West-Central region was estimated to be on the order of 2 or 3 percent of output (2.5 percent of shipments is used). All of these tires are assumed to be disposed of in the West-Central region.

5) Source: R.A.C., 08 May 1990, page 2 (personal communication):
Calculations by R.A.C. show the difference in annual auto registration versus new car sales. The difference is the number of vehicles taken out of service (sent to auto wreckers) in a year. This number includes those autos that are damaged beyond repair in accidents plus those scrapped through "old age".

The values calculated by R.A.C. are for 1988, however as tire sales have declined or stayed the same over the last two years, the figure is probably conservative.

Five tires per vehicle is assumed, with only light truck and passenger tires included, since conversations with individual auto wreckers and the Auto Wreckers Association of Ontario suggest that heavy trucks and industrial vehicles are not received by auto wreckers. The provincial total is prorated regionally by auto registration statistics.

Total tires "generated" by auto wreckers:

Total Passenger Tires:	1,328,980	(use 1.3 million)
Total Light Truck Tires:	719,665	
Total Tires	2,048,645	(use 2.0 million)
Total Passenger Tire Equivalents	2,396,615	(use 2.4 million)

See Note #13 for overall checks using these numbers and published tire shipment numbers.

6) Retread and Used Tire Sales figures are calculated from other data. Input and output quantities are the sum of all actions resulting in resale or retread. For example, Auto Wreckers, Tire Dealers, and Tire Jockeys all report sales of used tires; the total quantity of used tires sold is calculated as the sum of 720,100 (Auto Wreckers), 637,200 (Dealers) and 63,900 (Jockeys).

It was not possible to cross-check the used tire sales figures with another source. However, conversations with *Bandag Canada Limited* suggested that the total retread of heavy tires in Ontario is on the order of 300,000 tires virtually all of which are heavy truck tires. The figure shown of 1,351,200 retreaded passenger tire equivalents equates to about 260,000 heavy vehicle tires.

Figures from the U.S. Tire Retread Information Bureau indicate that retreaded passenger tire sales (from all sources) are about 10 percent of *new* passenger tire sales. Ontario tire dealers reported negligible light vehicle tire retread rates while tire jockeys claim about a 10 percent retread rate. However, all retreads by jockeys are actually exported and are not part of the Ontario demand for light vehicle tires.

7) Source: Tire Dealer Survey Summary
Due to the relatively small sample size per region, larger region areas were averaged in some cases. The disposal method estimates for the province are shown in Table 1 below. Regional and tire-type allocations accompany the tables in Appendix A.

See also Note #12 for a discussion of retreaded tire figures.

Table 1 - Disposal Methods Employed by Ontario Tire Dealers
(average for the sample)

Disposal Method	Landfill	Retread	Tire Jockey	Resale	Stockpile	Other
Percentage	59%	15%	14%	7%	4%	2%

8) Source: Stockpiler Survey Summary
Auto wreckers consistently reported about a 30% resale rate. This was confirmed by the Auto Wreckers Association of Ontario. The high resale rate is probably due to the number of vehicles scrapped in "fatal" auto accidents where the car may be wrecked, but the tires often remain serviceable. Auto wreckers claimed a high percentage of vehicles brought in by insurance companies. Auto Wreckers tended to stockpile half, and landfill half of all tires not suitable for resale. This ratio was also supported by the Association.

Very few auto wreckers interviewed had dealings with tire jockeys. Consequently, the number of tires transmitted through this route was assumed to be negligible (see below).

9) Source: Tire Jockey Survey Summary
No Tire Jockeys were identified in the South East, North East and North West regions. This was confirmed by tire dealers in the respective areas who indicated that they do not use tire jockeys. Dealers in all other areas reported using jockeys to some degree (see Note #7). The figure of about 1.3 million tires sent to Tire Jockeys derived from the Dealer Survey agrees well with figures provided by interviewed Tire Jockeys.

The following disposal options were calculated from data collected in the tire jockey survey, and assumed for all regions using their services (ie. South West, West Central, and Central Regions):

Landfill	Stockpile	Recycle	Export	Retread	Resale
25%	0%	50%	10%	10%	5%

All those interviewed maintained that almost no heavy vehicle tires were handled by tire jockeys. This was confirmed by tire dealers, and is reflected in the tables.

The number of tires collected from auto wreckers is also negligible, as virtually all tires accepted by jockeys originate from tire dealers. This was also confirmed by auto wreckers.

Tire jockeys employ a variety of recycling methods. Some are recycled on-site by the jockeys themselves (mainly the stamping of bias ply tires), however the majority are sent to one of the operating tire recyclers (see Recycling on page 21). Assuming a 50 percent recycle rate for *all* tire jockeys is probably liberal. It results in a total recycling quantity for the province of almost 700,000 tires, which is very near to the entire recycling capacity presently available in the province.

10) Retread/Resale tire final destination figures are based on the following assumptions:

- retreads/resales result in 100 percent scrap. ie. the replaced tire cannot be reused or retreaded; it may be recycled however, and note that:
- tire jockeys recycle twice as many tires as they landfill (see Note #9);
- All other sources of retread/resale tires landfill all tires replaced by the process.

11) Some landfills reported accepting off-spec tires from manufacturers. Consequently, all tires that the manufacturer scraps were assumed to be landfilled.

12) With Respect to Total Scrap Tire Generation:
The following calculations examine the total scrap passenger tire flow, and are used as a check of the rates derived. As can be noted, the results are highly consistent with the rates used in Figures 2 and 3.

Demand Side

New Vehicle Sales	660,000[3]
Increase in Registration	-235,000
----------------------------	-----------
Vehicles Removed per Year	425,000

Replacement Rate = (Vehicles Removed)/(Vehicles Registered)
= 425,000/4,500,000
= 8 to 10% per year
Average Auto Life = 1/(Replacement Rate)
= 1/(8 to 10% per year)
= 10 to 12 years

Assuming 2 or 3 tire replacements per auto lifetime,
Total Number of Tires Replaced per Year
= (Vehicles Registered)*(Number of Tire Replacements)*(5 Tires per Replacement)/(Average Auto Life)
= 6 to 8 million tires per year.

Supply Side

Total New Tires Shipped	4.5 million	
Used Tire Sales	1.3 million	(calculated)
------------------------------	-------------	
Total Tires Sold	5.8 million	

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[3] This calculation assumes that every new car sold is registered in the province. The change in vehicle registrations therefore, reflects the difference between new vehicle sales and the removal of older cars from the fleet.

2. Flows of Scrap Tires by Region

The flow of scrap tires by OMOE region and tire type is shown in the figures in Appendix A. Passenger tire and passenger tire equivalent generation rates have been calculated for each region.

3. Collection Costs

Tire dealers were the only group who were systematically asked for information on disposal costs. Most other generators (for example, auto wreckers) reported similar costs.

The average costs for tire disposal incurred by the dealers that were surveyed are tabulated below.

Table 2 - Average Scrap Tire Removal Costs by Region (per tire for the sample)

OMOE Region	Passenger	Light Truck	Heavy Truck	OTR Vehicle	Passenger Tire Equivalent
South West	$0.69	$0.89	$2.08	$2.32	$0.50
West Central	0.71	0.84	2.95	4.47	0.60
Central	1.27	1.82	6.07	9.85	1.23
South East	0.80	0.90	1.59	2.43	0.50
North East	0.34	0.40	0.83	1.22	0.23
North West	0.18	0.27	0.91	1.50	0.18
Average[4]	0.94	1.19	3.80	5.73	0.80

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[4] Averages are weighted by number of stores per region, which is assumed to be linearly related to published automobile registration figures.

4. Management Methods

Tables 3 to 16 show the number of tires going to and the cost per tire of each disposal option for each of the six OMOE regions. The proportions are derived from Figures 1 to 12 in Appendix A and Figures 1 and 2 in this chapter. Tables 3 to 8 show the management of passenger tires only for each of the six OMOE regions; Tables 9 to 14 show the same for passenger tire equivalents for each of the six OMOE regions; Table 15 shows the management of all passenger tires in Ontario; and Table 16 shows the handling of passenger tire equivalents in Ontario.

The tables cover 7 management options:

i) Landfill

This disposal option includes all tires on the property of landfills, either buried or piled for future use. The tipping fees indicated on the tables represent the average fee charged by landfills which accept tires; landfills which do not accept tires were not included in the calculation.

ii) Stockpile

Stockpiles cover tire piles on auto wreckers properties and on the properties of speculators. Stockpiled tires are often contaminated with dirt, water and sometimes insects and vermin. They are usually unsuitable for retreading, recycling, reuse or export.

iii) Recycle

Three tire recyclers are currently operating in Ontario. In theory 300,000 tires per year are being accepted by crumb producers. The blasting mat industry has the capacity to absorb 400,000 tires per year. (Blasting mats can only be made with 15" or 16" tires.) Both industries are prone to shut downs of operations, due to both equipment failure and market uncertainty, and are unable to accept tires at those times. The recycling option does not include the resale or retread of worn tires.

iv) Export

The export option includes all tires being exported out of the country, usually to the Caribbean or Mexico for reuse. Export includes casings which are retreaded and shipped out of the province.

At least one company has proposed exporting tires for the construction of artificial reefs in southeast Asia (as a means of encouraging fish growth). This too, involves the export of tires: however since a similar exercise has never been undertaken in Ontario, use of the term "export" is applied solely to the reuse of serviceable tires in another country.

v) Reuse

Reused tires include all used tires which are sold for use as a tire. This category does not include tires which are retreaded and then resold for further use.

vi) Retread

This option includes retreaded scrap tires which are sold for reuse in Ontario. The retreading process need not take place in the province. Presently, only retreaded truck tires are sold in Ontario; passenger tire casings are sold by tire jockeys to retreaders outside of the province where they are subsequently sold for further use. Casings which are retreaded and resold outside of the province are accounted for in the export management option.

Note: The reuse and retread options are not final disposal options. For every tire retreaded or resold there is another scrap tire generated for which the final destination will be one of the other five options.

vii) Other

This category includes tires used for erosion control, as well as all tires not accounted for in the other options such as those left in ditches, garages, car trunks, etc.

Management options for truck tires are more limited than for passenger tires. Truck tires are not presently used in any recycling operations because most shredders can not accommodate the large size. Blasting mat production is limited to 15" to 16" tires. Because of their high cost, truck tires are reused and/or retreaded, either by the original owner or by a stockpiler, until they are no longer serviceable, at which point they are landfilled or stockpiled by speculators. The price for a truck tire casing ranges between $80 and $100 and is applicable across the province. Conversations during the surveys indicated that a truck tire casing can be retreaded up to five times, with an average retread rate of three times per tire.

Tire jockeys have not been included in the list of disposal options since the acquisition of a tire by a tire jockey and the subsequent disposal of the scrap tire by the tire jockey would result in double counting. The tables show the final destination of the scrap tires, regardless of whether the disposal was accomplished by the original generator or through a tire jockey.

All known tire jockeys are operating out of the Central or West-Central region. However tire jockeys in the West-Central region service the Southwest region as well. It was therefore assumed that the percentage of tires handled by tire jockeys going to recycling, export and retreading, as well as the costs associated with each of those management options would be the same in both the Central and West-Central region.

The proportion of scrap tires handled in each region by tire jockeys is derived from surveys of dealers and auto wreckers.

5. Stockpile Information

Appendix B lists the locations and tire-handling characteristics of the forty stockpile operators interviewed.

DISPOSAL OPTIONS
PASSENGER TIRES ONLY
1989

TABLE 3
REGION: Central

Number of tires generated:	3 272 700
% of tires handled by tire jockeys:	21.4%

Option	Number	Percent	Cost (range)	Cost (median)
Reuse	443 500	14	-$5 to -$50	-$27.50 /tire
Retread	0	0	-$2	-$2.00 /tire
Landfill	1 908 350	58	$0 to $110	$55.00 /tonne
Stockpile	351 850	11	$1 (speculators only)	$1.00 /tire
Recycle	373 300	11	$0.20 to $0.65	$0.45 /tire
Export	140 000	4	-$1.50 to -$3.50	-$2.50 /tire
Other	55 700	2		

TABLE 4
REGION: Southwest

Number of tires generated:	1 272 500
% of tires handled by tire jockeys:	23.1%

Option	Number	Percent	Cost (range)	Cost (median)
Reuse	162 900	13	-$10 to -$30	-$20.00 /tire
Retread	0	0	-$1.30 to -$2.25	-$1.78 /tire
Landfill	750 400	59	$0 to $52	$26.00 /tire
Stockpile	120 500	9	$1 (speculators only)	$1.00 /tire
Recycle	156 700	12	$0.65 to $0.90	$0.78 /tire
Export	58 700	5	-$1.00 to -$3.00	-$2.00 /tire
Other	23 400	2		

Intermediate use	▨
Final disposal	☐

DISPOSAL OPTIONS
PASSENGER TIRES ONLY
1989

TABLE 5
REGION: West Central

Number of tires generated: 1 053 300
% of tires handled by tire jockeys: 17.8%

Option	Number	Percent	Cost (range)	Cost (median)
Reuse	133 200	13	-$10 to -$15	-$12.50 /tire
Retread	0	0	-$1.30 to -$2.25	-$1.78 /tire
Landfill	656 500	62	$136 to $137	$136.00 /tonne
Stockpile	111 000	11	$1 (speculators only)	$1.00 /tire
Recycle	100 200	10	$0.65 to $0.90	$0.78 /tire
Export	37 600	4	-$1.00 to -$3.00	-$2.00 /tire
Other	14 900	1		

TABLE 6
REGION: Southeast

Number of tires generated: 820 500
% of tires handled by tire jockeys: 0.0%

Option	Number	Percent	Cost (range)	Cost (median)
Reuse	107 200	13	-$10 to -$50	-$30.00 /tire
Retread	0	0	not available	
Landfill	605 000	74	$27 to $50	$38.50 /tonne
Stockpile	94 800	12	$0	$0.00 /tire
Recycle	0	0	$0.65 to $0.90	$0.78 /tire
Export	0	0	-$1.00 to -$3.00	-$2.00 /tire
Other	13 500	2		

Intermediate use ▨
Final disposal ☐

DISPOSAL OPTIONS
PASSENGER TIRES ONLY
1989

TABLE 7
REGION: Northeast

Number of tires generated:	227 300
% of tires handled by tire jockeys:	0.0%

Option	Number	Percent	Cost (range)	Cost (median)
Reuse	32 200	14	-$25 to -$60	-$20.00 /tire
Retread	0	0	not available	
Landfill	172 800	76	$0 to $9	$4.50 /tonne
Stockpile	22 300	10		
Recycle	0	0	*	
Export	0	0		
Other	0	0		

*blasting mat company operating in this region brings in all tires from other regions

TABLE 8
REGION: Northwest

Number of tires generated:	166 100
% of tires handled by tire jockeys:	0.0%

Option	Number	Percent	Cost (range)	Cost (median)
Reuse	20 100	12	not available	
Retread	0	0	not available	
Landfill	129 300	78	$0 to $14	$7.00 /tonne
Stockpile	16 700	10	$0	
Recycle	0	0		
Export	0	0		
Other	0	0		

Intermediate use	▨
Final disposal	☐

DISPOSAL OPTIONS
PASSENGER TIRE EQUIVALENTS
1989

TABLE 9
REGION: Central

Number of tires generated: 5 939 400
% of tires handled by tire jockeys: 12.8%

Option	Number	Percent	Cost (range)	Cost (median)
Reuse	689 400	12	-$5 to -$50	-$27.50 /tire
Retread	622 900	10	-$2 pass; -$80 to -$100 truck	
Landfill	3 368 300	57	$0 to $110/tonne	$55.00 /tonne
Stockpile	613 800	10	$1 pass.; $3 to $4 truck (speculators only)	
Recycle	405 300	7	$0.20 to $0.65	$0.45 /tire
Export	152 000	3	-$1.50 to -$3.50	-$2.50 /tire
Other	87 700	1		

TABLE 10
REGION: Southwest

Number of tires generated: 2 430 500
% of tires handled by tire jockeys: 13.1%

Option	Number	Percent	Cost (range)	Cost (median)
Reuse	250 800	10	-$10 to -$30	-$20.00 /tire
Retread	305 900	13	-$1.30 to -$2.25 pass;-$80 to -100 truck	
Landfill	1 389 700	57	$0 to $52	$26.00
Stockpile	211 900	9	$1 (speculators only)	
Recycle	169 800	7	$0.65 to $0.90	$0.78 /tire
Export	63 600	3	-$1.00 to -$3.00	-$2.00 /tire
Other	38 700	2		

Intermediate use	▨
Final disposal	☐

DISPOSAL OPTIONS
PASSENGER TIRE EQUIVALENTS
1989

TABLE 11
REGION: West Central

Number of tires generated:	1 661 500
% of tires handled by tire jockeys:	12.0%

Option	Number	Percent	Cost (range)	Cost (median)
Reuse	201 800	12	-$10 to -$15	-$12.50 /tire
Retread	91 800	6	-$1.30 to -$2.25 pass;-$80 to -$100 truck	
Landfill	1 015 700	61	$137 to $150/tonne	$144.00 /tonne
Stockpile	186 600	11	$1 pass.; $3 to $4 truck (speculators only)	
Recycle	106 300	6	$0.65 to $0.90	$0.78 /tire*
Export	39 900	2	-$1.00 to -$3.00	-$2.00 /tire
Other	19 800	1		

TABLE 12
REGION: Southeast

Number of tires generated:	1 644 600
% of tires handled by tire jockeys:	0.0%

Option	Number	Percent	Cost (range)	Cost (median)
Reuse	180 100	11	-$10 to -$50 pass; -$80 to -$100 truck	
Retread	192 200	12	-$80 to -$100 truck	
Landfill	1 076 200	65	$27 to $50/tonne*	$38.50 /tonne*
Stockpile	172 400	10	$0 - auto wreckers only	
Recycle	0	0		
Export	0	0		
Other	23 800	1		

*passenger tires only; truck tires up to $15 each

Intermediate use	▨
Final disposal	☐

DISPOSAL OPTIONS
PASSENGER TIRE EQUIVALENTS
1989

TABLE 13
REGION: Northeast

Number of tires generated: 603 100
% of tires handled by tire jockeys: 0.0%

Option	Number	Percent	Cost (range)	Cost (median)
Reuse	63 000	10	-$25 to -$60 pass	-$42.50 /tire
Retread	85 300	14	-$80 to -$100 truck	-$90.00 /truck
Landfill	413 600	69	$0 to $10/tonne	$5.00 /tonne
Stockpile	41 200	7	$0 - no speculators	
Recycle	0	0	*	
Export	0	0		
Other	0	0		

*blasting mat company operating in this region brings in all tires from other regions

TABLE 14
REGION: Northwest

Number of tires generated: 384 800
% of tires handled by tire jockeys: 0.0%

Option	Number	Percent	Cost (range)	Cost (median)
Reuse	36 000	9	not available	
Retread	53 100	14	-$1.30 to -$2.25 pass;-$80 to -$100 truck	
Landfill	263 300	68	$0 to $14/tonne	$7.00 /tonne
Stockpile	32 400	8	*	
Recycle	0	0		
Export	0	0		
Other	0	0		

*small percentage going to a speculator was recorded in stockpiler surveys but did not appear in dealer surveys

Intermediate use	▨
Final disposal	☐

TABLE 15

SCRAP TIRE DISPOSAL: PASSENGER TIRES

ONTARIO: 1989

Number of tires generated:	6 812 300
% of tires handled by tire jockeys:	17.3%

Option	Number	Percent
Reuse	889 100	13
Retread	0	0
Landfill	4 222 200	62
Stockpile	717 000	11
Recycle	630 200	9
Export	236 300	3
Other	107 500	2

TABLE 16

SCRAP TIRE DISPOSAL: PASSENGER TIRES EQUIVALENTS

ONTARIO: 1989

Number of tires generated:	12 663 900
% of tires handled by tire jockeys:	10.1%

Option	Number	Percent
Reuse	1 421 100	11
Retread	1 351 200	11
Landfill	7 526 600	59
Stockpile	1 258 100	10
Recycle	681 400	5
Export	255 500	2
Other	170 000	1

▨	Intermediate use
☐	Final disposal

C. Summary and Conclusions

1. Regional Differences

Scrap Tire Generation

The generation rate of scrap passenger tires is proportional to automobile registration. The percentage of new tire sales in each region closely matches regional registration statistics and the assumption of this relationship for used and retread tire sales produces provincial totals that agree well with tire demand (section B.1.12 on page 19, 157). The distribution of scrap tire generation varies from motor vehicle registration by less than 2 percent per region when other tire types are included.

The South-East, West-Central, and Central Regions show the highest rates of passenger scrap tire generation, from all sources, in Ontario. When heavy vehicle tires are included the percentage generated by the peripheral regions (South East, South West, North East and North West) increases, while the percentage generated by the West Central Region decreases. These rates were derived primarily from automobile registration and tire sales figures[5]. A higher proportion of heavy vehicle sales in peripheral region dealerships appeared in the dealer survey summary as well.

In all of the southern regions, passenger tires represent over 80 percent of sales by volume, with a high of 92 percent in the West Central Region. The portion for the northern regions is closer to 70 percent. The value changes significantly when passenger tire equivalents are considered. In southern regions, passenger tires represent about 60 percent of sales by weight (except for West Central where the 1989 value is closer to 75 percent): in the northern regions, passenger tires represent less than half of the total weight of all tires sold.

These ratios seem to indicate that the sale of heavy vehicle tires in peripheral regions may skew Ontario's overall generation of tires by passenger tire equivalent. However, due to the sheer volume of units sold in the central regions, the breakdown for Ontario is about 86 percent sales by volume and 62 percent by weight (almost exactly that of Central Region).

Management Costs

Table 2 highlights the management costs by region and tire type currently experienced by the tire dealers surveyed. Clearly Central Region, generating the largest number of scrap tires also pays the highest cost per tire for handling, with other southern regions close behind. The availability of landfill sites that do not charge tipping fees in both northern districts accounts for the relatively low costs faced by dealers there.

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[5] The registration of vehicles is totalled by vehicle type.

The fact that the cost for a passenger tire equivalent is usually slightly less than for a normal passenger tire indicates that disposal of heavy tires is not priced strictly according to weight.

2. Major Barriers to Higher Value Uses

Retreading

Very few passenger tires are retreaded in Ontario. Although some retread of light vehicle tires is known to occur (mostly of light truck tire casings), most dealers interviewed do not sell *any* retreaded light vehicle tires. Consequently, the provincial average for the light vehicle retreading rate is assumed to be zero.

Conversely, a high percentage of heavy vehicle sales are retreads. The average obtained from the survey is nearly sixty percent. (The calculations indicate that retreads amount to about 14 percent of total shipments by weight.)

Dealers indicated aesthetic as well as economic barriers to higher retread sales in the passenger tire market. Those that do retread however, indicated that dealers obtain high margins on retread sales, and that more retreads could be sold if marketing efforts were increased. Most consumers view the price difference between retreaded tires and new tires as not worth the perceived loss in safety.

The initial cost of new heavy truck tires, and the aggressive refund schedule (most dealers give between $80 and $100 for a good heavy truck tire casing) contribute to the high retread rates for heavy truck tires. Some dealers noted that commercial tire retreading is slowing due to owner's tendencies to prolong tire life, which renders fewer casings suitable for retreading.

Resale

Survey results indicate that, depending on the handler, between 10 and 30 percent of used passenger tires are resold (the overall Ontario average is about 14 percent). Used tires face the same sort of aesthetic barriers as retread, but have a distinct economic advantage: the cost of additional processing is not required. Used tires are usually only about one-quarter the price of new ones. Still, it is unlikely that this percentage will rise much.

A look at the flow net figures shows that resold and retreaded tires do not directly reduce the quantity of tires disposed since our charts assume that the tire replaced by the retreaded/reused tire must in turn be disposed. Instead, these intermediate destinations reduce the demand for *new* tires, and hence, do result in an overall reduction of tire disposal requirements.

Recycling

Economics is one of the major barriers to recycling tires. The costs of disposal (Table 2) faced by Ontario tire dealers establish a ceiling on what recyclers can charge scrap tire generators. Since tire dealers directly handle about three-fourths of scrap tires (by weight), recyclers must charge less per tire than the costs shown or recycling will not become a significant factor in scrap tire management. The problem is exacerbated in regions with very low scrap tire disposal costs.

3. Other Significant Findings

Effect of Hagersville fire on disposal options and costs

Most speculators have stopped accepting tires since the Hagersville fire. The cost of complying with the imposition and enforcement of fire safety regulations has made the business of accumulating tires no longer economic for most stockpilers.

Since the fire, the charge to dispose of a tire with a stockpiler has increased dramatically. Whereas the charge to accept a passenger tire was generally $1 before the fire, dealers have reported quotes from speculators of up to $10 per tire to dispose of their tires since the fire.

Tire jockeys report a significant increase in business since the fire, since they often provide the only legal option to dispose of tires. However the sudden halt in speculator's accumulations since the fire, and the frequent increases in tipping fees, has resulted in a dramatic rise in operating costs for tire jockeys.

Effect of increased tipping fee on the legal disposal for scrap tires

The Keele Valley landfill servicing Metro Toronto has been recording the number of tires disposed since 1987. When the tipping fee was $18 per tonnes an average of 413 tonnes of tires were received per month at the landfill. The table below traces the relationship between tipping fees and tonnage of tires received.

Table 17 - Tipping Fees and Tire Quantities Accepted at Surveyed Ontario Landfills[6]

Period	Tipping fee per tonne	Change in tipping fee	Average tonnes of tires received per month	Change in average tonnes of tires received per month
1987 to March 1988	$18	0%	413	0%
April 1988 to April 1989	$50	170%	471	+14%
April 1989 to January 1990	$85	70%	275	-42%
February 1990 to March 1990 (post Hagersville fire)	$85	0%	400	+45%

The number of tires disposed at the landfill significantly decreased only when the tipping fee rose to $85 tonne. After the fire the number of tires arriving at Keele Valley increased sharply again, averaging about 400 tonnes per month, almost identical to the number of tonnes being received before the tipping fee increases.

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[6] Source: Bob Innis, Metropolitan Works Department, personal communication

III. EVALUATION OF PROCESSING TECHNOLOGIES

A. Methodology

A tire's useful life on a vehicle typically consumes only about 20 percent of its original weight, leaving 80 percent of its original materials content for recovery from the scrap tire. The effectiveness and potential efficiency of a scrap tire management program is directly related to the utilization of this potential resource. The objective of this chapter is to evaluate the technical and economic factors involved in scrap tire recycling.

The sources of information used in the analysis are as follows:

(1) a literature review of scrap tire recycling technologies used throughout the industrialized world,

(2) direct experience of one of the study team members in scrap tire recycling,

(3) interviews with all of the key players in Ontario's scrap tire management industry, and

(4) interviews with representatives of government departments and others with an interest in scrap tire recycling.

All major known technologies have been included. Although a number of variations of each technology exist, these variations will not have a significant impact on the conclusions of this analysis.

Technologies have been separated into four major categories for the purposes of this discussion: whole tire applications, physical processing, chemical processing, and energy utilization.

B. Whole tire applications

Retreading has historically been the largest application for whole tire recycling. However passenger tire retreading has consistently declined during the last 15 years and this trend is expected to continue. The decline is generally attributed to the following factors: (1) decreased use of retreaded snow tires since the introduction of all-season radial tires; (2) availability of new tires at costs comparable to quality retreads; and (3) public perception of poor quality and reliability of retreads. In contrast, retreaded truck tire sales have increased due to the larger price differential between new and retreaded truck tires as well as professional management of fleet tires to preserve casing integrity for retreading.

Many other imaginative uses have been developed for whole tire reuse, including the traditional tire swing, landscape borders, playground equipment, dock bumpers, erosion control, highway crash barriers, artificial reefs, and breakwaters. Over 2,000 artificial reefs have been constructed, primarily in salt water environments, with good results provided the tires are properly banded, ballasted, and anchored in appropriate oceanographic conditions. Usage has been limited by costs ranging from $1.00-5.00 per tire depending upon ballasting, anchoring, transportation, and placement requirements. Limited work in fresh water environments within Ontario has been less successful due to the slower rate of tire encrustation in fresh water.

Golden Transfer (Toronto) has proposed using whole tires as part of a patented stabilization system for tailings piles resulting from mining operations. These piles typically remain unstable and unattractive because of their inability to support tree growth and vegetation. By interlocking tires over the tailings piles and covering them with a mixture of tailings and ash from the incineration of waste water treatment sludge, vegetation and tree growth could be enhanced. The sludge incineration ash supposedly provides organic and inorganic nutrients which improve growth-support characteristics of the ash/tailings mixture. The interlocked tire grid serves simply as a sub-surface support structure intended to maintain stability of surface vegetation. In addition to beautifying the landscape, Golden Transfer believes this approach would provide a site for ash disposal and resulting tree growth would enhance atmospheric oxygen levels. The process would use 50,000 tires per hectare and there are many candidate sites in northern Ontario. Application costs would depend upon transportation distances, but Golden Transfer believes an existing 16 hectare tailings pile in the Timmins area could be covered at a cost of $2.00-$3.00 per tire.

C. Chemical Processing

Scrap tires can be processed to recover chemical constituents through degradation processes which break the cross-linked high molecular weight elastomers present in tires into lower molecular weight components. Historical examples include rubber reclamation and pyrolysis.

1. Reclamation

Rubber reclamation involves degradation of the vulcanized rubber structure by mechanical, thermal or chemical processes. The structure itself may be viewed as long parallel strings (representing long-chain natural or synthetic polymers) inter-connected by short cross-strings (representing sulphur bonds introduced during vulcanization). It resembles a window screen with carbon black filling the void areas. Reclamation processes sever few of the sulphur cross-link bonds, but significant degradation of the basic polymer chain occurs. The resulting product resembles small pieces of the screen including carbon black. Reclaim retains some characteristics of a shorter-chain polymer structure, but the reclamation process does not yield the equivalent of virgin raw materials due to retained cross-linking, severed polymer chain length, and inherent carbon black. Following the visual representation, reclaim is like small pieces of the screen.

Prior to the mid-1940s, tires were made from natural rubber, carbon black, curatives and other components spread uniformly throughout the tire. As a result, reclaimed rubber reflected this uniformity and was suitable for use in low-performance applications or as an extender. Five to twenty percent reclaim (generally 5 to 10 percent) was used in new tires without compromising the limited performance standards of the time. Typical tire life was 5,000 to 10,000 miles. According to The R.T. Vanderbilt Rubber Handbook, reclaimed rubber accounted for 23 percent of total rubber purchases in 1941, including non-tire applications. By 1943, reclaim represented 38 percent of total purchases due to limited virgin rubber availability during World War II. A "Victory Tire" was even made for passenger cars from virtually 100 percent reclaim, but its performance characteristics were extremely poor. Military specifications still limited reclaim usage to 15 percent maximum for performance reasons.

Manufacturing research has resulted in a series of performance advances achieved through use of synthetic elastomers and tire design modifications. Elastomers and carbon blacks were specifically optimized for each section of the tire, with different compounds for casing, sidewall, and tread. This evolution has resulted in today's superior tire performance characteristics, including a life cycle of 40,000 to 60,000 miles. It represents an excellent example of the first principle of waste management, namely reduction in quantity. By achieving a long life cycle, potential scrap tire volumes have been proportionately reduced by a factor of 3 to 10, depending on the base period chosen. In addition, today's tires meet much more stringent safety and performance standards. Tire manufacturers continue to devote major global research efforts to further enhance tire life for simple competitive reasons. However, with current technology, longer tire life requires unacceptable compromises in traction, ride and overall safety.

This tire evolution has had one negative impact. A tire's complexity and non-uniformity results in a reclaimed rubber which is a variable mixture of elastomers and carbon blacks, and generally does not meet the high standards of specifically tailored virgin materials used in tires. Small percentages of reclaim are still used in some lower-performance tires, larger off-road tires, retread stock, and non-tire applications. Less than one percent of total rubber purchases are now reclaim. Many facilities, including virtually all of those operated by major tire producers, have closed during the last 25 years. There are no reclaim producers in Ontario or Canada and capacity of the remaining U.S. plants is currently under-utilized. Completing the earlier visual representation, a screen made from small non-uniform pieces cannot be expected to have the characteristics of a new, uniform screen.

In summary, reclaim usage in tires does not represent a technically feasible option for recycling a major portion of Ontario's scrap tires. With the less complex tire chemistry of the 1940s, only 5 to 10 percent reclaim was generally used. With today's tires, similar or higher general usage would probably cause a counter-productive reduction in life cycle resulting in disproportionately greater scrap tire generation.

2. Pyrolysis

Pyrolysis generates oil, gas, and other products through thermal decomposition of tires in an oxygen-limited environment. The ratio and composition of these product streams depends upon the process, temperature, pressure, and residence time. The combustible gas typically represents 10-25 percent of the product stream and is used to fuel the process or adjacent combustion equipment. The oil is generally 35-60 percent of the product and varies in quality from saleable fuel oil to lower value blend stock. The char stream constitutes 25-40 percent and contains a mixture of carbon blacks, titanium dioxide (from white sidewalls) zinc oxide (a vulcanization accelerator), and steel (bead and radial reinforcement).

Pyrolysis is not a new process. Over the last twenty years, many processes, equipment and operating variations have been applied to scrap tires. A U.S. Department of Energy publication entitled "Scrap Tires: A Resource and Technology Evaluation of Tire Pyrolysis and Other Selected Alternate Technologies" identified 31 pyrolysis projects utilizing fluidized beds, travelling grate chambers, rotary kilns, retorts, molten salt and hot oil baths, plasma units, and microwave chambers as reactors. Various operating conditions have been extensively explored to optimize production and quality of product streams.

Extensive technical and economic resources (an estimated $100 million) have been invested in projects developed by major companies such as Goodyear/Tosco (The Oil Shale Co.) Firestone, Occidental, Uniroyal, Nippon, and Foster-Wheeler. In addition, many pilot or "demonstration" projects have been developed by smaller companies and entrepreneurs. The most recent major project developed by Foster-Wheeler in England (Tyrolysis) failed technically and economically after expenditures in excess of $30 million.

The major reasons for project failure include the following:

(1) Operating Problems: Utilizing complex equipment at high temperatures with an abrasive feedstock is generally maintenance-intensive. Downtime and maintenance expenses often have been underestimated in projections.

(2) Safety: Operating in an oxygen-limited, high temperature environment creates an inherent vulnerability to fires or explosions resulting from accidental air infiltration. Such accidents have destroyed or damaged numerous facilities, including complete destruction of the $6 million Intenco operation in Houston, Texas.

(3) Feed Availability and Processing: The scale required for economic feasibility can be greater than the availability of tires within a reasonable service area. Capital and operating costs associated with shredding or feed preparation have often been underestimated.

(4) Product Quality: It is difficult to optimize quality and yields of three inter-related product streams (gas, oil and char) since conditions favouring one often have a negative impact on another. Due to the mixture of carbon blacks and other constituents in the char, it has historically only been suitable for low value applications with limited market volumes, even when further processed to control size uniformity and iron content.

(5) Environmental Impact: Tires contain about 1.2 percent sulphur and 0.7 percent zinc, by weight. These inorganic materials are not destroyed in operations, so they will be present in one or more of the product streams (as established by a mass balance) depending upon conditions, along with partially burned hydrocarbons. This must be reflected in appropriate emissions control and product quality/value assessments.

(6) Economics: The economic feasibility of pyrolysis is dependent upon many operating factors such as system reliability, capital and labour costs, process, feedstock preparation expense, environmental control requirements and product revenue. Operations with reasonable tipping fees have historically not been achievable without development of high-value ($0.12-0.25 per kilogram) markets capable of absorbing total char volumes.

Although pyrolysis has not historically proven to be technically and economically feasible under conditions similar to those in Ontario, future developments may change this. However, in view of this history, several key questions should be addressed in examining possible projects for a significant role in Ontario's scrap tire program: (1) Have the process and economics been demonstrated on a scale representative of a commercial operation? (2) Have product quality, variability, market volumes, and pricing been demonstrated and documented? (3) Does the process incorporate appropriate emission control equipment to minimize environmental impact? (4) Do capital, operating, and maintenance cost estimates accurately reflect historical operations and provide adequate allowances for any applicable fuel preparation and environmental controls?

Two Ontario stakeholders have identified pyrolysis process variations. Emery Associates in Bowmanville has initiated development of a process which utilizes a high efficiency microwave system. By utilizing microwave energy, tire rubber is pyrolysed at low temperatures with only the reinforcing wire being heated. Claims by Emery based on limited small scale testing include: (1) Generation of a high quality oil; (2) Possible capture of elemental sulphur; (3) Production of char saleable locally at $0.12 per kilogram (but the identified potential customer denied any interest in purchasing the material); (4) No significant emissions; (5) Projected daily operating rates of 3,000 whole tires per full scale continuous process train. Development and testing of a larger batch system capable of processing whole tires was scheduled to begin in April, with grant assistance provided by the Ministry of Energy. Meaningful capital cost, operating expense, product quality, and revenue estimates cannot be developed due to the early stage in the development of the process.

Ibis Products Limited in Scarborough is participating in development of a pyrolysis char upgrading process in conjunction with Tire Tech in Toledo, Ohio. The process is proprietary but reportedly involves mechanical steps to remove steel and control particle size. Modifications of material handling equipment are under consideration to improve throughput rates. Economics cannot be established until capacities and operating costs have been demonstrated.

Product testing and market assessments for the char have been initiated by a consulting company and potential distributor. Initial product testing shows properties between standard grades N600 and N700 of carbon black. The N700 series is classified as semi-reinforcing furnace (SRF) grade used predominately in moulded rubber goods. The higher quality N600 series is considered general purpose furnace (GPF) grade used in casing compounds. The combined potential U.S. market for these grades was estimated at 390 000 tonnes per year. A pyrolysis plant processing one million tires per year at 30 percent char yield (2,700 tonnes per year) would require market penetration of less than one percent. Pricing is projected at well over $0.22 per kilogram. Production and evaluation of commercial quantities will be required to establish market penetration and pricing. Previous mechanical and chemical char upgrading processes have not proven to be economically viable. However, if Ibis' process is successfully demonstrated, they hope to combine the upgrading system with a technically sound pyrolysis process to achieve a profitable system that will meet the criteria outlined above.

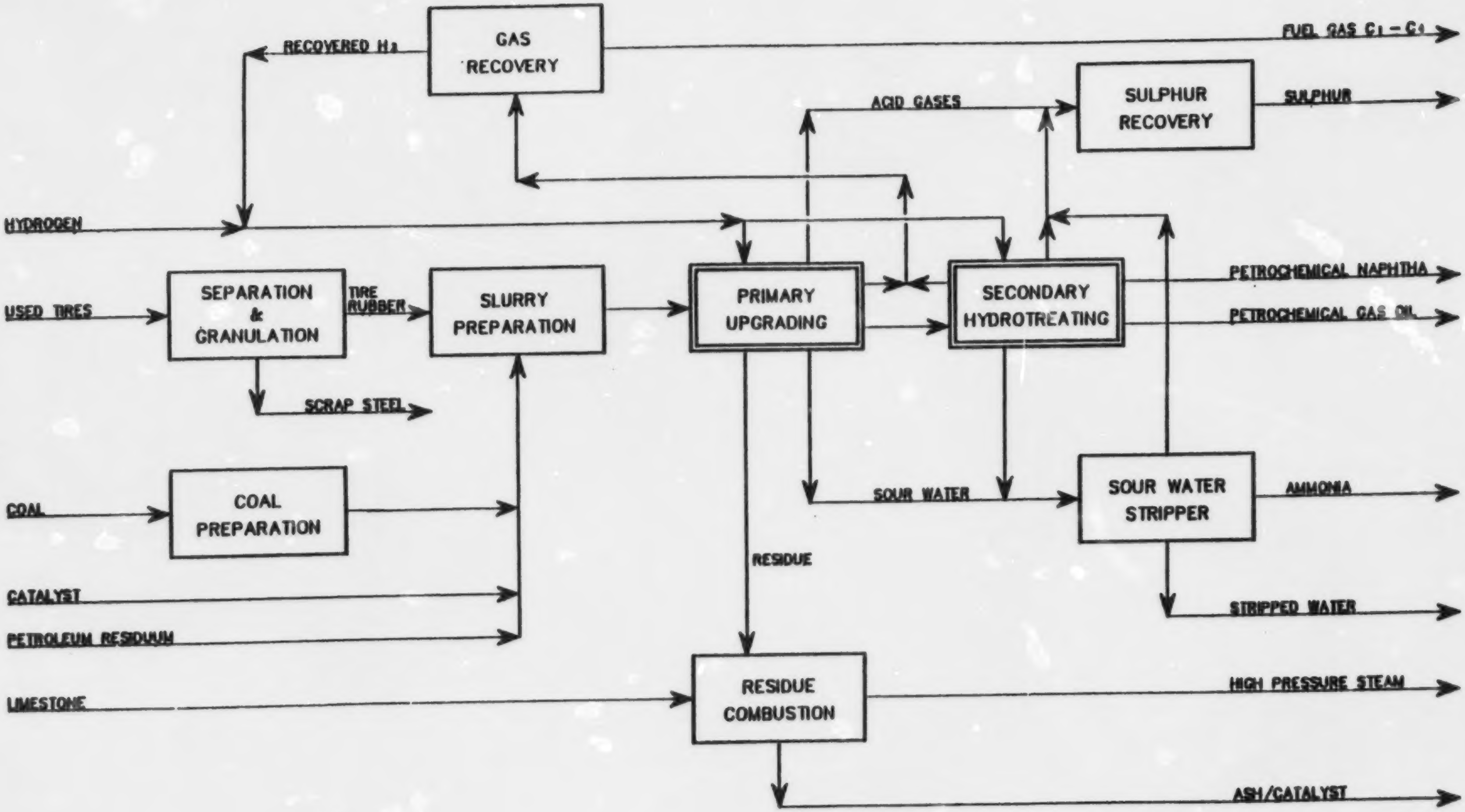
3. Petroleum slurry processing

Kilborn Limited is examining a process to convert crumb rubber into naphtha, a basic chemical building block. A process flow diagram is provided in Figure 4. Simply stated, a slurry consisting of crumb rubber, coal and petroleum residue, is subjected to hydrogenation and hydro-treating to convert the slurry to naphtha. The process utilizes technology which has been commercially demonstrated with coal, but development steps are required to verify the feasibility of the process when rubber is included in the slurry.

A commercial scale unit would require almost 80,000 tonnes of crumb rubber per year or the equivalent of 7 to 8 million tires. The preliminary capital cost, including crumb rubber production facilities, is roughly $130 million if constructed at a specific refinery site in Ontario. Payout is projected to be 6.9 years at a tipping fee of $2.00 per tire and 3 to 4 years at $3.00 per tire. A series of three progressively larger-scale demonstration trials would be required prior to final design of the system. Testing, design, and construction would require at least three years before commercial operation. Long-term rubber crumb availability would be required.

If successfully applied in Ontario, the process could convert almost all of the province's scrap tires into a basic petrochemical. However, the cost, time delay, and long-term commitment would be considerably greater than other options.

Figure 4



PRELIMINARY BLOCK FLOW DIAGRAM
USED TIRES TO PETROCHEMICALS

D. Energy utilization

Scrap tires have a high energy content of 30,000 to 33,000 kJ/kilogram, which is roughly equivalent to hydrocarbon feedstocks from which they are manufactured. This energy can be recovered by combustion of whole or shredded tires as an alternative to traditional fossil fuels. The environmental impact of inorganic compounds present in tires must be carefully evaluated in selecting appropriate applications. The various energy utilization alternatives and their potential applicability within Ontario is discussed in the following sections.

1. Whole tire combustion

Small quantities of whole tires are burned as part of municipal solid waste (MSW) introduced into mass-burn units. Large quantities of segregated tires are typically not burned for these reasons:

(1) The high heat-release rates associated with tire combustion can cause localized temperatures exceeding design conditions for grates intended to burn low-energy MSW.

(2) Sulphur oxides (SO_x) and particulate emissions can increase if environmental controls are not designed to efficiently remove them; and

(3) Combustion controls can be affected by rapid heat release from multiple tires;

(4) Since combustion units are generally heat-release limited, burning tires in this manner may be an expensive disposal option if the system is capacity limited -- each tonne of tires displaces the ability to burn roughly three tonnes of MSW.

Quantities of segregated tires have been burned in several specific MSW and refuse-derived fuel boilers, including those in Akron, Ohio, Palm Beach, Florida, and Pinellas, Florida. However, percentages are generally limited to less than 10 percent by heat value, for environmental reasons. The tires are shredded and mixed with the waste to avoid hot-spots and control problems. Due to the limited number and capacity limitations of Ontario incinerators, this approach does not provide significant tire disposal volume.

Specially designed furnaces have operated exclusively with whole tires, generating electricity and/or steam. Small units have been operated by Gummi-Mayer in Germany. The first large unit capable of converting 400,000 tires per month into 14.5 mW of electricity began operation in Modesto, California in 1987 at a capital cost of $42 million (U.S.). The plant has experienced initial difficulties in operation reliability and permit compliance, which reportedly are being corrected. As a result, the plant has experienced operating losses in spite of electricity revenue of $0.085/kWh. Each $0.01/kWh decrease in electricity revenue requires a tipping fee increase of approximately $0.25 per tire to maintain a constant rate of income generation. At a rate of $0.04/kWh, which is typical for Ontario, an additional tipping fee of at least $1.12 per passenger tire (equivalent) would be required to maintain equivalent total revenue.

Whole tires have also been utilized as a supplemental fuel in cement kilns in England, Germany and the United States, displacing up to 20 percent of the energy otherwise supplied by coal. Cement kilns have used either whole or shredded tires as a fuel. The choice between the two forms is generally based upon evaluation of the following site-specific factors:

1) kiln type and configuration,
2) metering system logistics and control requirements,
3) metering system capital and operating costs,
4) availability and cost of whole versus shredded tires,
5) combustion controls, and
6) heat replacement objectives.

Utilization of tires in cement kilns is further discussed in the next section.

2. Shredded Tire Supplemental Fuel Usage

The energy content of tires can also be utilized by shredding tires into uniform pieces, called tire-derived fuel, (TDF) for use as a supplemental fuel in appropriate, existing power boilers and kilns. Usage is generally limited to 2 to 20 percent displacement (by heat content) of traditional fossil fuels (oil, gas, and coal) by combustion and environmental considerations. Fuel characteristics, production economics, potential markets and environmental considerations are provided below.

Fuel Characteristics

The chemical and physical characteristics of tire-derived fuel varies depending upon the production method, tire source, and degree of wire removal (if any). Typical characteristics of TDF with and without inherent steel belted radial reinforcement wire are illustrated in Table 18. Actual analysis of an individual tire chip may vary by manufacturer, storage time, tire segment, and other factors. In addition to iron, TDF ash contains approximately 1.8

percent zinc oxide, 0.4 percent calcium oxide, and trace quantities (less than 0.01 percent) of other metals like cadmium, lead and chromium.

The physical characteristics of TDF depend upon the manufacturer and its customers' requirements. Quality TDF typically consists of sharply cut chips averaging 5 centimetres by 5 centimetres in size with minimal long stringy pieces or wire pigtails that can impede handling or metering systems. Larger chips may be acceptable in some applications if they are compatible with handling equipment and combustion conditions. TDF is typically stored outside with leaching concerns limited to gradual dissolution of exposed wire. If TDF is accidentally ignited, it tends to burn only on the surface. As a result, it is more readily extinguished than whole tire piles due to higher TDF volumetric density which limits oxygen exposure, and heat conduction within the pile is decreased by the absence of long, continuous steel cords present in whole tires.

Table 18
Characteristics of Tire-Derived Fuel

Characteristics	TDF With Wire	TDF Without Wire
Heat Value (kJ/kg)	13,500 - 14,500	14,800 - 15,500
Proximate Analysis (weight %)		
Ash	15	5
Volatile Matter	60	67
Fixed Carbon	25	28
Total	100.0	100.0
Elemental Analysis (weight %)		
Carbon	75.5	84.4
Hydrogen	6.3	7.1
Nitrogen	0.2	0.2
Sulphur	1.1	1.2
Oxygen (by difference)	1.9	2.1
Ash	15.0	5.0
Total	100.0	100.0

Production Processes and Economics

TDF production processes range from single tire shredders to complex systems involving a series of shredders, screens, wire liberation and wire removal equipment. TDF production is generally considered a demonstrated technology but process and equipment optimization is still evolving. Many companies provide tire shredding equipment with a wide range of processing capabilities and capacities. Examples include Mitts-Merrill, Columbus-McKinnon Triple-S, Eidal, Shredding Systems, National and many others. However, the combination of rubber's resiliency and wire's abrasiveness make tire shredding more difficult than expected. Production capacities are normally lower than expected due to unscheduled downtime. Maintenance costs are typically higher due to equipment wear.

The capital and operating costs associated with TDF production vary widely depending upon the process, volume, product specifications, and site-specific factors (labour, power rates, available auxiliary equipment, building requirements, etc.). In general, the simplest systems require either a high capacity shredder with recycling screens for chip size control or a series of smaller shredders with interim/final product screening.

In either case, total installed equipment cost generally ranges from $400,000 to $600,000 plus land, building, electrical supply, front end loader, site preparation and maintenance supplies. Storage of whole tires and tire-derived fuel on pavement minimizes contamination. Placing equipment under cover assists operations and maintenance.

Estimated production costs for a basic operation producing a nominal 5 centimeter chip containing inherent wire is provided in Table 19 for low volume (1 000 tires per eight hour shift) and high volume (6 000 tires per eight hour shift) operations. Capital and operating costs shown in Table 19 are estimates for a facility in Ontario. The additional capital reflected in the higher volume operation includes such items as a dedicated loader, automatic feed system, and additional property requirements. Actual capital and operating costs may differ significantly depending upon the specific operation and equipment, but it is clear that economics are extremely volume sensitive due to the basic labour, support, and capital required for the operation.

Table 19
Estimated TDF Production Costs

	Low Volume	High Volume
Capital and Operating Costs		
Capital ($000)	$600	$750
Depreciation (5 yr straight line)		
Labour		
Foreman @ $30,000/year	1	1
Laborers @ $20,000/year	2	3
Maintenance @ $25,000/year	1	1
Electrical		
HP @ 0.75 kw/hp x $0.05/kWh	160	260
G + A		
Insurance (5% of capital, $000)	30	38
Clerical @ $15,000/year	1	1
Office @ $1,500/month		
Maintenance Materials ($/tire)	$0.10	$0.10
Capacity		
Hourly (tires/hour)	170	1 000
Availability	75%	75%
Annual (000 tires/year @240 days/yr)	240	1 440
Cost per Tire		
Labour	$0.39	$0.08
Electrical	0.05	0.02
Maintenance	0.10	0.10
G + A	0.26	0.05
Sub Total (per tire)	$0.80	$0.25
Other*	0.75	0.16
Total (per tire)	$1.55	$0.41

* Other includes depreciation, debt service, and profit. It is estimated as 30 percent of capital costs.

The volume sensitivity increases if significant fixed resources are devoted to management or marketing activities which were not included in the example. Typical tire shredding operations in the United States have represented costs of $0.40 to $1.00 per passenger tire equivalent depending on volume and local power/labour rates.

Production and management costs may be partially offset by the value (net of transportation) realized from the sale of TDF, if any. Depending upon this value, TDF facilities can operate at reasonable volumes with tipping fees ranging from $0.25 - $1.00 per tire depending on product revenue.

Potential Markets

TDF has been utilized in many industrial applications capable of using solid fuels. The major traditional markets have included cement kilns and stoker-fired power boilers in the paper industry. Fluidized bed boilers and lime kilns also represent potential applications, but current experience is limited.

Tires, either whole or in TDF form, are currently being used as a supplemental fuel in cement kilns in England, Germany, Belgium, Japan, Greece, Mexico and the United States. Initial usage by Blue Circle Industries (England) and Heidelberg Cement (Germany) reportedly began over 15 years ago. Calaveras Cement (California) pioneered U.S. development of TDF energy utilization in the mid-1970s, with at least eight other kilns now using TDF commercially or experimentally in Texas, Oregon, Washington, Ohio, Kentucky, Colorado, Florida and Arizona.

Cement kilns represent a large potential market for TDF because of their high energy consumption, operating conditions that are conducive to environmentally-acceptable combustion, and sensitivity to cost savings that may be achieved through alternative fuel usage. The quantity and method of TDF introduction depends upon the specific kiln type. Dry pre-heater or pre-calciner kilns typically use up to 20 percent (by heat displacement) TDF (or whole tires) introduced by a conveying system into the riser or pre-heater sections of the system. An additional 5 to 10 percent displacement may be achieved by blowing TDF into the product end of either wet or dry kilns. Quantity and introduction method must be carefully controlled to avoid localized reducing zones which would have a negative impact on product quality and kiln operations. A list of cement kilns in Ontario is provided in Table 20 and summarized by kiln type in Table 21.

Table 20
POTENTIAL TDF USERS
Ontario Cement Manufacturers

Kiln Data

Company	Location	Distance from Toronto (km)	Type	Built	Cement Capacity ('000 t/yr)	Fuel	Comment
Lafarge Canada	Bath	225	Dry-Pre-heater	1973	943	C(G)	Water Access
Lafarge Canada	Woodstock	130	Wet	1956	254	C(O,G)	
			Wet	1957	251		
Lake Ontario	Picton	210	Dry	1956	173	C(G)	Water
			Access				
			Dry	1956	173		
			Dry	1965	286		
			Dry	1975	790		
St. Lawrence	Mississauga	15	Wet	1956	279	C(O)	Water Access
			Wet	1957	279		
			Dry	1967	1 302		
St. Marys**	Bowmanville	65	Wet	1969	300	C	
			Wet	1974	300		
St. Marys	St. Marys	175	Wet	1955	127	C(G)	
			Wet	1964	127		
			Dry	1977	737		
Total Ontario					6 321		

* Fuel Symbols: C = Coal, O = Oil, G = Gas
Primary fuel stated first, alternative fuel in ( ).

** An additional pre-calciner kiln with a capacity of over 1 000 tons/year is under construction and scheduled for operation in 1991.

Table 21
Cement Kiln Summary

Province of Ontario

Cement Manufacturers: 4
Plant Locations: 6
Kiln Profile:

Type	Wet	Dry	Pre-heater	Total
Number	8	6	1	15
Capacity (in tonnes/yr)	1 917	3 461	943	6 321
% Total Capacity	30%	55%	15%	100%
Average Capacity/Kiln	264	636	1 040	465

Potential TDF usage can be roughly estimated for various kiln types by correlating energy requirement, percentage heat displacement, and annual kiln production. For instance, TDF consumption by a dry kiln using 4 million kJ/tonne of product, 20 percent TDF heat displacement and an annual capacity of 1 000 000 tonnes per year would be calculated as follows:

> 1 000 000 tonnes product/year x 4 000 000 kJ/tonne x 20 percent displacement ÷ 28 000 000 kJ/tonne TDF = 28 571 tonnes of TDF per year or the equivalent of over 3 million passenger tires per year.
>
> Calculated similarly, wet kilns using 5 million kJ/tonne and 10 percent heat replacement could use the equivalent of about 2.0 million tires per 1 000 tonnes of clinker production. Based upon type and stated operation, identified Ontario kilns could potentially use over 13 million passenger tire equivalents per year. Realization of this total potential is unlikely, but kilns have been viewed within Europe and the U.S. as an opportunity to utilize the energy content of tires (in preference to stockpiling) until higher value applications are developed.

The capital required for TDF usage in kilns is generally limited to fuel metering systems (constructed at a cost of $100,000-$300,000), plus testing required to demonstrate environmental acceptability. St. Marys Cement in St. Marys, Ontario has requested approval to conduct a TDF trial burn to demonstrate technical feasibility and environmental acceptability. St. Marys' kiln could use up to 2.5 tonnes of TDF per hour or the equivalent of 2.0 million tires per year if the trial is successful. The TDF would displace about $1 million in annual purchases of Pennsylvania coal with actual fuel savings depending upon availability and delivered pricing of TDF. If the trial is permitted and is successful, it is likely that other cement companies would pursue TDF usage to avoid being at a competitive disadvantage.

The second major historical application for TDF has been in stoker-fired power boilers within the pulp and paper industry. These boilers typically burn wood waste to generate steam and electricity for internal consumption. Fossil fuels like coal, oil, or gas are often used to maintain boiler control and demand response. TDF can be introduced, at 2 to 10 percent heat-value displacement, with the wood waste to displace fossil fuel usage and enhance complete combustion of wet wood. TDF has been used in power boilers since the mid-1970s in Oregon and Washington, and is currently being used by major corporations in Wisconsin, Maine, Virginia, Georgia, Alabama and California. The required quality of TDF is generally more stringent in this application than in cement kilns. Bead wire removal may be required to avoid grate fouling which results in increased maintenance expense and/or equipment outages.

A list of identified Ontario pulp and paper plants, with their associated fuels is provided in Table 22. Potential for TDF usage has been preliminarily categorized based on available data, including site, boiler type and fuel usage. Those in category 1 represent most likely customers for TDF, 2 is for possible customers, while 3, 4, and 5 are progressively less probable. Definition of actual TDF potential requires detailed screening of boiler operating specifications, fossil fuel usage, economics and environmental controls. Since this screening was beyond the scope of this study, it is difficult to accurately estimate possible TDF usage. However, some U.S. mills of comparable size to those designated as Category 1 have demonstrated their ability to use 10 to 15 thousand tonnes of TDF (1 to 1.5 million passenger tire equivalents) per year. As with the cement kilns, the capital cost associated with TDF usage is limited to inexpensive fuel metering systems (generally $50,000 - $100,000) and environmental testing costs.

Ontario Hydro has considered the possibility of using TDF to displace one to three percent of the coal burned at its Lambton generating station. Other Ontario coal-fired generating stations could also burn TDF, but the Lambton station is the only one that is currently equipped with SO_x scrubbers, which would be required to control SO_x emissions if TDF is burned. Before TDF could be used on a regular basis at the Lambton station, Ontario Hydro would have to carry out a trial burn to determine how to best blend the fuel, where and when to inject the TDF, and to monitor stack emissions. Ontario Hydro is paying $55 to $90 per tonne of coal with a heating value of 22 000 to 25 000 kJ per kilogram, and has been quoted $140 per tonne of suitable TDF with a heating value of about 33 000 kJ per kilogram. It would, therefore, appear that for TDF to be economically attractive to Ontario Hydro its cost would have to be brought down. Estimates of the number of scrap tires that Ontario Hydro could consume as TDF are not available.

Table 22
POTENTIAL TDF USERS
Ontario Pulp and Paper Plants

Company	Location	Boiler Data		Category	Distance from Toronto (km)
		No.	Fuel*		
IKO Industries Ltd.	Brampton	1	G	6	-
Sonoco	Brantford	1	G/O	5	100
Domtar, Inc.	Cornwall	2	G/O	3	435
Great Lakes Forest Products	Dryden	2	WW/G	2	1 715
E.B. Eddy Forest Products	Espanola	3	G/O/C	1	455
Boise Cascade Canada, Ltd.	Fort Francis	4	G	4	1 710
Trent Valley Paperboard Mills (East)	Glen Miller	3	G/O	5	170
(West)	Glen Miller	1	G/O	3	170
CIP	Hawkesbury			5	490
Kimberly Clark, Ltd.	Huntsville	2	G/O	5	215
Abitibi-Price, Inc.	Iroquois Falls	3	G/C/W/B	2	760
Kimberly-Clark Ltd.	Kapuskasing			4	840
Spruce Falls Power & Paper Co.	Kapuskasing	5	G/C/B	1	840
Boise Cascade Canada, Ltd.	Kenora	4	B/G/O/C	1	1 855
James River-Marathon Ltd.	Marathon	3	G/C/B	2	1 100
Domtar Packaging	Mississauga	2	G/O	4	-
Strathcona Paper Co.	Napanee	2	G/O	4	230
Nordfibre Co.	North Bay	2	C/G/B	3	345
E.B. Eddy Forest Products, Ltd.	Ottawa	4	G	4	400
Domtar Packaging	Red Rock	5	G/O/B	1	1 235
St. Marys Paper Inc.	Sault Ste. Marie	3	G/O/B	2	690
Atlantic Packaging Products, Ltd.	Scarborough	2	-	4	-
Malette Kraft Pulp and Paper	Smooth Rock Falls	1	HF/G	1-2	780
Domtar, Inc.	St. Catharines	1	G/O	4	110
Kimberly Clark of Canada Ltd.	St. Catharines	-	G/O	5	110
MacMillan Bloedel Ltd.	Sturgeon Falls	3	G/C/W	2	390
Kimberly Clark of Canada Ltd.	Terrace Bay	1	O/B/Sludge	1	1 100
Beaver Wood Fibre Co.	Thorold	3	O/G	4	130
Domtar Construction Materials	Thorold	2	G	4	130
Fraser Inc.	Thorold	3	O/G	4	130
Quebec and Ontario Paper Co. Ltd.	Thorold	5	G/O	2	130

Table 22 continued
Ontario Pulp and Paper Plants

Company	Location	Boiler Data No.	 Fuel*	Category	Distance from Toronto (km)
Abitibi-Price Inc. Port Arthur Division	Thunder Bay	4	G/B	2	1 375
Abitibi-Price Inc. Fort William Division	Thunder Bay	2	G/O	3-4	1 375
Abitibi-Price Inc. Thunder Bay Division	Thunder Bay	3	G/C/B	2	1 375
Great Lakes Forest Products Ltd.	Thunder Bay	6	G/C/B	1	1 375
Belkin Paperboard	Toronto	2	G/O	4	-
Dominion Cellulose Ltd.	Toronto	-	G/O	4	-
Domtar Inc.	Toronto	1	G	5	-
Domtar Packaging	Trenton	2	O/G	5	-

* Symbols: G = gas, O = oil, W = wood waste, B = bark, C = coal, HF = hogged wood fuel

Environmental Factors

TDF cannot and should not be used in all potential combustion applications. Although tires are hydrocarbon-based and exhibit combustion characteristics similar to coal and oil, tires also contain previously cited inorganic constituents which must be carefully considered in determining environmental acceptability. The two primary elements of concern are sulphur and zinc oxide.

Tires contain 1.1 to 1.2 percent sulphur by weight. On a heat equivalent basis, this equates to a sulphur level of 0.9 to 1.0 percent in coal containing 26 000 kJ/kilogram. For comparison purposes, most coal supplied to Ontario from neighbouring U.S. states (Illinois, Ohio, Pennsylvania and New York) have a sulphur content of about 2 percent or almost twice the effective sulphur content of TDF. Western coal is typically 0.6 to 1.0 percent sulphur which is lower than, or comparable to, TDF. The type of coal used by specific customers depends upon comparative cost, environmental controls, and permit requirements. Tires also contain 1.5 percent zinc oxide used as an accelerator in the vulcanization process. The ultimate fate of both materials must be identified to assess their environmental impact.

As previously mentioned, tires and TDF are considered environmentally acceptable fuels in proper applications within Europe and the United States. Attempts to identify environmental standards in Europe did not result in specific guidelines due to current variations and rapid changes occurring as part of the European Economic Community's uniformity initiatives.

However, Table 23 compares Ontario's emissions standards with those proposed by the U.S. EPA and the proposed European Economic Community (EEC) standards for 1992 and 1999. The Ontario and U.S. standards are more stringent than the EEC 1992 standards, but less stringent than the EEC 1999 proposal. European countries have historically allowed long time periods for companies to initiate compliance measures. As a result, applications deemed acceptable in Europe may not be appropriate in the United States or Ontario.

The U.S. Clean Air Act regulations require new sources to utilize Best Available Technology (BAT) to meet New Source Performance Standards (NSPS). Examples include ammonia injection for NO_x control, a baghouse or electrostatic precipitator for particulate, and caustic scrubbing for SO_x. Any variations have to be justified and demonstrated. When retrofitting equipment or modifying existing permits (as required with a fuel change such as TDF usage), emissions must remain within previous permit limitations and conform to PSD (prevention of significant deterioration) criteria which limit additions to the operating baseline (even if the result remains within the permit limits). Examples of PSD criteria include maximums of 40 tons/year of SO_2 and NO_x, 25 tons/year of total suspended particulate, and 40 tons/year of criteria pollutants (volatile organic compounds). It is within these rigorous standards that TDF usage has been permitted in U.S. cement kilns and power boilers.

TDF use in cement kilns has proven to be environmentally acceptable for several unique reasons:

> (1) Cement kilns utilize extreme combustion conditions, including high temperature, turbulence and residence time which assure optimum degradation of organics.
>
> (2) Kilns provide residence times of 2 to 4 seconds at temperatures over 1 200°C. Pre-heater sections provide almost three seconds of temperatures over 870°C, and six seconds over 540°C. The limestone present in the kiln provides sulphur removal to prevent SO_x emissions.
>
> (3) Zinc, wire, and other ash constituents become an integral chemical part of the cement product, replacing alternative raw materials required to maintain proper cement chemistry.

As a result, kilns have generally demonstrated their ability to thoroughly burn and contain emissions from TDF.

Table 23

International Emission Standards Equivalents

Regulatory Agency Emission Standards (milligrams/standard dry cubic meter)

	Proposed US-EPA	EEC 1992	Proposed EEC-99	Ontario
Particulate	37.0	50.0	8.4	20
CO	61.0	168.6	84.3	30-35
NO_x	228.6	None	118	100-150
SO_x	57.6	505.8	67.4	50-75
HCl	20.0	84.3	16.9	50

Notes:

(1) Particulate values are corrected to 12 percent CO and 20°C, while other values are corrected to 7 percent 0_2 and 20°C.

(2) EEC standards are for facilities using over 3 tonnes/hour.

(3) Ontario Emission standards are based on the ambient concentrations at a specified point downwind (point of impingement) of the stack. The concentrations shown in the table are estimates of allowable stack emissions.

Consideration of paper mill boiler applications generally requires closer evaluation and lower acceptable maximum usage limits. If TDF displaces higher sulphur coals produced in neighbouring U.S. states, SO_x emission may actually decrease. Alternatively, many wet scrubbing systems operated at basic pH may control SO_x emission increases to within acceptable limits. Zinc oxide particulate emissions are best controlled by a system with an electrostatic precipitator (ESP) or baghouse. With lower maximum TDF usage (2.5 percent by heat content), wet scrubbers generally provide acceptable removal. Total particulate emissions can actually decrease in some systems with electrostatic precipitators because TDF decreases wood-based particulate through enhanced combustion, and ionized zinc oxide from TDF is more efficiently removed.

In summary, combustion applications are not the highest value recycling use for scrap tires, but the comparative cost of market development and low entry capital may make proper TDF application an attractive alternative to stockpiling while higher value uses are being developed. Since most other applications require a chipped raw material, TDF products may simply be diverted to higher value feedstock uses (like crumb rubber) as other markets grow. Since TDF has relatively low value per pound reflecting competitive fuel price, developmental applications offering higher materials recovery value should inherently displace TDF. If necessary, incentives could be provided to enhance this displacement through development or support of materials recovery markets. However, interim use as a fuel has been deemed to be environmentally and economically preferable to stockpiling or landfilling by all major industrialized nations.

E. Physical processing

Mechanical and cryogenic processes are capable of converting scrap tires into fine rubber granules called crumb rubber. Particle size distribution ranges from 10 to 200 mesh, with the most common products being 10-50 mesh. Coarser 10-50 mesh products resemble ground pepper, while finer 100-200 mesh products approach talcum powder in size. Crumb rubber generally maintains the chemical and physical characteristics of tire rubber and is used for these material properties. Production methods and product markets are discussed below.

Crumb rubber has been produced by ambient and cryogenic processes for over 20 years. Buffing dust from retreading operations and other waste rubber materials have often been used as raw materials for crumb rubber in preference to whole tires to minimize capital and operating costs as well as to control or narrow product polymer content.

Cryogenic Processing

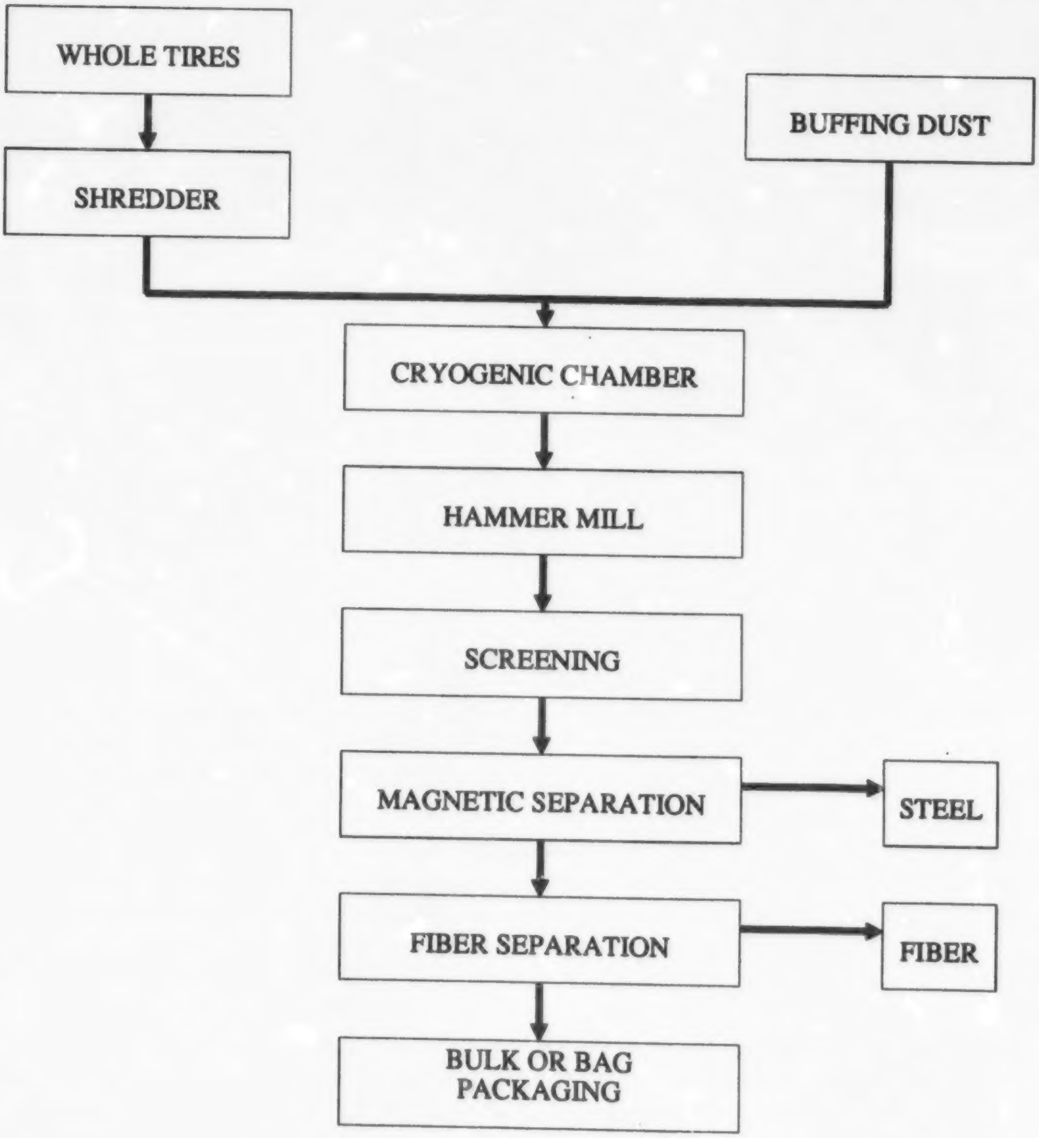
Cryogenic processes utilize liquid nitrogen to freeze rubber prior to size reduction. The cold rubber becomes brittle and is readily shattered into fine particles in a hammermill. Fabric/wire liberation is enhanced and power consumption is reduced by cryogenic processing. The final product retains the high density characteristics of the original rubber. Cryogenic crumb rubber tends to be cubical in shape with smooth surfaces which are conducive to easy handling and flowability. Although production process components can vary widely, typical major steps in the cryogenic process are illustrated in Figure 5.

Capital and operating costs are extremely sensitive to site-specific conditions, process variations, and use of reconditioned or new equipment. Two Ontario-based companies, Ontario Tire Recycling and Recovery Technologies Inc., are proposing to establish cryogenic processing facilities in Ontario. Capital costs for Ontario Tire's planned system, which is based on used equipment purchased from Midwest Elastomers (Ohio), are estimated to be $1.5 to 2.0 million for a capacity of 1.2 million tires per year. Recovery Technologies' proposed plants, using new equipment, are estimated to cost about $3 million for capacity of 1.3 to 1.5 million tires per year.

The major component of cryogenic operating cost is nitrogen which can range from $0.12 to 0.18 per kilogram of product depending on feedstock sizing, efficiency, nitrogen purchase price and product yield. Electricity, labour and plant-related overhead generally add $0.15 to 0.26 per kilogram of product with the higher cost incurred in whole tire shredding operations. Total production costs range from $0.27 to 0.44 per kilogram, or about $1.89 to 3.08 per passenger tire equivalent. Most U.S. cryogenic crumb rubber producers have closed due to non-competitive manufacturing costs.

FIGURE 5

CRYOGENIC CRUMB RUBBER PROCESS COMPONENTS



Cryogenic Crumb Rubber Stakeholders

Custom Cryogenic Grinding Corporation (Waterford) has been cryogenically grinding rubber-based waste materials into crumb rubber for eleven years with its main current market being friction brake pad products sold in the United States. Custom Cryogenic uses only buffing dust and other rubber wastes from tire manufacturing as raw materials to control the polymer properties and quality of its products. Whole tire crumb rubber contains mixtures of the different elastomers present in treads, sidewalls and internal bladders which have a negative impact on product quality and consistency. Its cryogenically produced crumb rubber tends to be cubical and flow easily, making it suitable for friction products.

Custom Cryogenic also uses cryogenic processes to pulverize plastics. As a result, Custom Cryogenic has a logical interest in exploring product and market potential for rubber and plastic mixtures. The company is currently conducting a research project with Ortech International to explore the impact of various bonding additives on mixed product performance characteristics. This represents a first step in developing product and market knowledge required for commercial production of formulated resin-rubber mixtures.

Due to formulation requirements, Custom Cryogenic will not manufacture whole-tire crumb rubber unless growth in demand exceeds availability of current feedstock sources.

Ontario Tire Recycling (Port Colborne) is in the process of constructing a cryogenic system utilizing equipment purchased from Midwest Elastomers in Ohio. Projected capacity is 1.2 million tires per year using a processing sequence which includes shredding, cryogenic freezing, hammermill pulverization, magnetic separation, air classification, and product screening. Ontario Tire Recycling projects total operating costs to be about $0.18 per kilogram, but actual historical costs have been higher and significant market development expenses will be incurred. Ontario Tire Recycling has extensive experience in scrap tire collection and has a substantial tire pile at Port Colborne. Ontario Tire Recycling realizes net tipping fees of $65/tonne at its Welland yard. A $23,000 market survey was commissioned to examine U.S. crumb markets, and based upon this analysis, Ontario Tire Recycling does not expect any difficulty in marketing its products into applications as diverse as plastic pellets, mats, and sound barriers. However, intense competition will be encountered at existing customers and extended developmental lead times are required in most new applications. Ontario Tire Recycling anticipates construction of two additional plants to support planned market requirements, but timing will depend upon product demand.

Recovery Technologies Inc. (Ayr) has assumed the cryogenic rubber processing assets of Retico after its bankruptcy. Recovery Technologies is currently developing its production and marketing strategies prior to starting production. The company claims to have identified markets totalling 20,000 tonnes (equivalent to more than 2,000,000 tires) of crumb rubber per year within 200 kilometres of Toronto. Examples of applications include athletic tracks and compression moulded products such as mats and industrial flooring. Recovery Technologies expects to achieve plant capacity of 450 tonnes per month within 12 months of start up. The company has stated that it plans to construct 3 to 5 additional plants within three years, each with capacity of 7,000 tonnes per year at a capital cost of $3 million for each plant. Actual expansion will depend upon development of new product markets.

Ambient Grinding

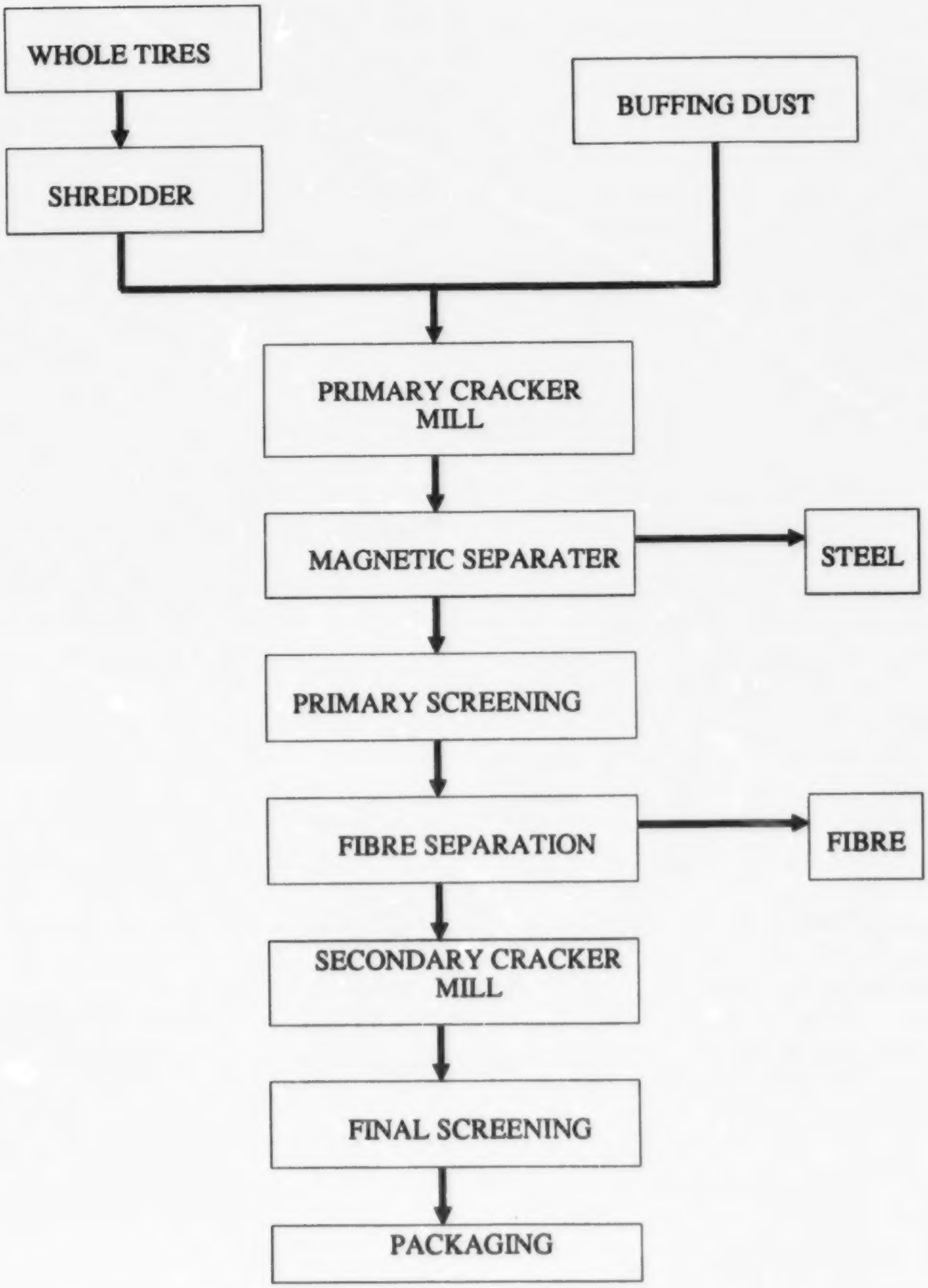
Ambient grinding processes utilize mechanical shear and compression forces to produce tire granules. Heat is generated in the process, and must be controlled to avoid creation of molten rubber. A typical process flow diagram for ambient crumb rubber production is shown in Figure 6. There are numerous variations of equipment sequences and components depending upon product quality requirements and production scale. In some cases, granulators are substituted for, or staged in conjunction with cracker mills. Fabric can be removed by air classifiers, gravity tables, and/or aspirators. Steel removal is accomplished magnetically, often with differing types of magnets at multiple points in the process.

Estimates of capital costs for an ambient grinding facility can be based on the recent construction of Resource Recovery's facility in Orangeville. Actual capital cost was $750,000 for a facility processing 350,000 tires per year. The capacity of this facility may be expanded to one million tires per year at an additional investment of $1.0 to 1.5 million. Operating costs are highly sensitive to feedstock, capacity, local labour rates, electrical costs, equipment configurations, product size distribution, and marketing expense. Total operating costs cited by industry sources and references range from $0.18 to 0.26 per kilogram for coarser 10 mesh products to $0.22 to 0.32 for finer, high-purity 30 to 50 mesh products.

Resource Recovery Orangeville is one of only two existing Ontario crumb rubber producer using whole scrap tires as a raw material. (The other is National Rubber.) Resource Recovery started operations in early 1989 and is currently processing approximately 30,000 passenger tire equivalents per month (350,000 per year). The plant uses shredding followed by a series of cracker mills to produce coarse and fine crumb rubber products. Fabric is removed by aspirators and gravity methods. Steel is collected magnetically. All products are currently being sold for sport surfaces and moulded rubber parts. The plant has experienced normal initial operating difficulties associated with shredder performance and process optimization. Resource Recovery is planning to expand capacity to one million tires per year as rapidly as possible to service identified market demand, then progressively increase capacity in one million tires per year increments as additional markets are secured. The plant is reportedly operating profitably with a tipping fee of $0.60 per passenger tire. The company's future success is dependent upon its ability to establish operating consistency and maintain markets as competition increases.

FIGURE 6

AMBIENT CRUMB RUBBER



Thermal-Friction-Screw-System

In addition to traditional mechanical production methods, a demonstration facility has been installed in the Toronto area using a series of Thermal-Friction-Screw processes to produce crumb-rubber. The equipment is manufactured by ATS in Switzerland, and distributed exclusively by Thermo Friction Waste Recycling Inc. (TWR) in Canada. The process utilizes the shearing and compression of two parallel variable flight screws operating against adjustable friction plates to disintegrate the rubber.

The process requires three screw presses to control product particle size and liberate wire from rubber. Wire removal is accomplished with multiple magnets. Fabric could be removed by air classification, if required, but is not included in the existing process. Removal would increase capital costs and decrease projected crumb rubber yield. The process is being optimized to control heat generation within the presses, product size distribution and yields. Long-term reliability and maintenance costs are difficult to project based on limited production to date. TWR and Comrep Systems Inc. are attempting to develop specific moulded rubber product markets to support construction of future plants.

Economic projections for a facility within the Toronto area have been prepared by TWR/Comrep. Estimated capital cost is $2,970,000 for a plant processing three tonnes of shredded tires per hour, 20 hours per day, 250 days per year. Such a plant would process 1.6 million tires per year into 15,000 tonnes of crumb rubber (including fabric). Total operating costs are projected at $0.165 per kilogram. With a net tipping fee of $0.80 per tire and crumb sales at $0.20 per kilogram, projected annual return on capital exceeds 50 percent.

Crumb Rubber Markets

The size of crumb rubber markets have historically controlled the number of scrap tires that have been recycled for their materials value. A comprehensive market study conducted by Waste Recovery for the State of Minnesota in 1984 identified merchant North American crumb rubber usage in Table 24.

Table 24
NORTH AMERICAN CRUMB RUBBER USAGE

Market Segment	Annual Volume 1984 (Thousand tonnes)
Moulded Rubber Products	3.6 to 5.5
Friction Brake Materials	2.3 to 3.6
Pneumatic Tires	4.5 to 6.8
Athletic Surfaces	3.6 to 5.9
Asphalt Rubber	7.7 to 10.0
Miscellaneous	1.4 to 2.3
Total	23.1 to 34.1

Although more recent detailed survey data are not available, limited market growth is suggested by the fact that North American crumb rubber production capacity existing in 1984 is still operating at an estimated capacity utilization rate of less than less than 60 percent. There has been little capacity expansion, and the largest new plant (Rubber Research Elastomerics of Babbit, Minnesota) was operating at 15 percent of capacity when it failed two years after start-up. Industry estimates place total current demand at about 50 thousand tonnes per year, with most of this being produced from buffing dust, peelings, or alternative waste rubber sources. Probably less than 30 percent of current crumb rubber production is based upon whole scrap tire rubber, representing less than 3 million tires per year. The following is a summary discussion of major market segments and identified Ontario stakeholders.

Traditional Markets

Traditional markets for crumb rubber generally include moulded rubber products, friction brake materials and pneumatic tires. The latter two are mature applications with demand dependent more on economic cycles than inherent growth. However, demand for moulded rubber products appears to be growing due to: new products being introduced, a greater virgin rubber price differential, and public acceptance of products containing recycled materials. The greatest growth appears to be in moulded rubber parts for automotive use and mats for various purposes including livestock habitats. Preference by some public segments for products incorporating recycled materials may lead to growth of additional market segments. Many of these applications may require expensive molds and/or market development efforts for consumption of relatively small quantities of crumb rubber.

National Rubber Company Inc. is the largest independent manufacturer of recycled, masticated rubber products in North America. The company was founded in Toronto in 1927, and operated as a private company until 1969 when it was sold to the Allen Group Inc. The company founders remained active in management of the company for the next 20 years. In 1989 the founders and a merchant banking group purchased National Rubber from the Allen Group. National Rubber currently has manufacturing and warehouse facilities in Metropolitan Toronto representing a cumulative investment of about $70 million. Sales are estimated to be about $50 million per year. National Rubber employs about 500 people.

The majority of National Rubber's production is exported to the United States. The automotive industry is an important market for National Rubber, with 40 percent of its products made from recycled materials going to the motor vehicle manufacturers. The remaining products using recycled rubber are sold in a broad base of consumer and industrial markets.

Like all Canadian manufacturers that depend heavily on the United States automotive parts market, National Rubber is being negatively affected by the rapid increase in the value of the Canadian dollar, high interest rates, shrinking margins, and a downturn in motor vehicle markets. National Rubber's plants are currently operating at about 60 percent of capacity.

National Rubber currently uses about 24 000 tonnes per year of various types of scrap rubber to produce a number of automotive, industrial, and consumer products. Of this total, the company currently purchases 10 000 to 12 000 tonnes of vulcanized crumb rubber from scrap tires and 12 000 to 14 000 tonnes of other types of waste rubber. National Rubber purchases the majority of Ontario's current crumb rubber production, but available quantities represent only a small portion of their requirements. As a result, the company obtains over 80 percent of its tire-derived crumb rubber from United States sources and virtually all of its other rubber wastes from outside of Canada.

National Rubber has submitted a proposal to OMOE which would increase its consumption of crumb rubber produced from Ontario's scrap tires through the three methods outlined below.

(1) ***Displacement of U.S.-sourced crumb rubber.*** Domestic crumb rubber purchases could be increased by 10 to 11 thousand tonnes (equivalent to approximately 2.0 to 2.5 million passenger tire equivalents) per year through displacement of United States products if capacity, quality, reliability, and pricing were competitive with existing suppliers.

(2) ***Displacement of alternative rubber raw materials.*** National Rubber is confident that crumb rubber from scrap tires will be able to displace up to 70 percent of other waste rubber raw materials used in its current range of products. This would be equivalent to up to an additional two to three million passenger car tires per year. Annual expenditures of about $500 000 would be required for reformulation of rubber compounds, manufacturing process development and product testing over a three year period before this potential can be fully realized.

(3) ***Product development/market growth.*** National Rubber has extensive experience in turning scrap tires into end use products which it believes can be utilized to expand existing markets and develop new ones. National Rubber has indicated that it is continuously working on product and market development both in the automotive and non-automotive markets. Current budgets restrict the speed at which these can be accomplished. With additional funding for product and market development National Rubber believes that it could expand production to consume an additional two to three million passenger tire equivalents.

National Rubber has stated that, with appropriate financial support, it could potentially expand its use of tire-derived crumb rubber, over the next five years, to the point that it would be capable of consuming all of the scrap tires generated in Ontario.

1. Athletic Surfaces

The primary usage of crumb rubber in athletic surfaces is in running tracks and playground surfaces requiring resiliency, grip and durability. Many of these applications currently use tire buffings because buffings consist of long, narrow rubber pieces which increase resiliency and durability. However, crumb rubber usage may increase as buffings become less available and alternative polymer blends become less dependent on fibre resiliency.

Two companies in Ontario, specializing in athletic surfaces, were identified and interviewed. Sportbau Canada in Mississauga is a ten year old company specializing in installation of rubberized urethane surfaces. Annual purchases of crumb rubber are directly dependent upon specific projects, but 100 tonnes have been ordered in 1990 for use through June, and total 1990 consumption is projected at 230 to 270 tonnes. A competitive, all-weather track such as one installed in Kitchener can use 100 tonnes of crumb rubber. Playground surfaces 30 to 50 mm thick require about 2.7 kilograms of rubber per square meter, at a typical cost of $107 per square meter. Sportsbau purchases rubber from Ontario and U.S. sources, but rubber represents a small part of the total installed cost. Sportsbau believes that rubber consumption could be significantly increased if all playgrounds were required to be surfaced with resilient materials to decrease injuries and public liability.

Elastocrete in Mississauga also installs safety and sports surfaces. Due to cost and performance considerations, the company internally processes buffings from heavy truck tire retreading operations to obtain their annual requirements of about 230 tonnes. Some experimentation with higher cost crumb rubber at levels up to 50 percent has been initiated as a hedge against limited buffings supply. Mechanically ground crumb rubber is preferable due to greater surface bonding area.

In summary, the athletic surface market segment appears to offer only limited potential (less than 100,000 passenger tire equivalents per year) in Ontario.

2. Rubber in Asphalt

Use of crumb rubber as an additive in asphalt formulations for highway applications represents a potentially large market. The (U.S.) Asphalt Rubber Producers Association has estimated that all scrap tires could be consumed in highway construction if rubberized asphalt proved to be technically and economically acceptable for widespread application. However, market penetration of rubberized asphalt has been limited by the need to carefully evaluate technical and economic performance factors prior to its widespread use. Highway design engineers must consider the impact of rubber in asphalt on many interrelated performance criteria including stability, durability, flexibility, fatigue resistance, skid resistance, impermeability, and workability as well as environmental factors. Premature general use of any paving system can result in expensive failures, especially for systems like rubberized asphalt that involve significantly higher initial installed costs than traditional asphalt.

Highway design engineers use various asphalt application methods to prevent, retard, or correct specific symptoms of highway deterioration. Major applications which have historically used rubberized asphalt include the following:

1) Stress Absorbing Membranes (SAM) consisting of a rubberized asphalt mixture applied over existing pavement to retard fatigue cracking.

2) Stress Absorbing Membrane Interlayers (SAMI) involving rubberized asphalt application under asphaltic concrete to prevent reflective cracking.

3) Chip Seals consisting of a sprayed rubberized asphalt layer and subsequent aggregate placement to prolong surface life through improved impermeability, wearability, and skid resistance.

4) Crack Sealants consisting of rubberized asphalt binder injected into highway cracks to retard moisture penetration and roadbed deterioration.

Of these applications, SAMs and crack sealants have been most widely tested and used. When properly applied, rubberized asphalt crack sealants have generally proven to be technically and economically feasible, but the total market represents a relatively small crumb rubber consumption volume. Some difficulties have been reported with increased flammability during on-site asphalt recycling and with proper application.

Rubberized asphalt or asphalt rubber are generic terms referring to the introduction of crumb rubber into asphalt mixtures. However, varying methods can be used for rubber introduction, blending, curing, and application. The four major types of rubberized asphalt are briefly described below:

The "Arizona" System - The original system involved pre-reaction of about 20 percent finely ground crumb rubber (20 to 50 mesh) with paving grade asphalt to create a rubber-modified binder which is then blended with aggregate to form the paving mixture. The process is patented by Karl Jacobson of International Surfacing and royalties are paid by contractors using the technology. The process requires specialized equipment to pre-react, pump, and apply the rubberized asphalt mixture. A 1 to 1.5 percent increase in asphalt binder (from 6 percent in standard asphalt to about 7.2 percent in this system) is required to compensate for rubber absorption, and extender oils may be required to control viscosity. All of the above factors increase installed cost and vulnerability to improper installation. The system uses about 25 tonnes of crumb rubber (roughly 5,000 passenger tires) per kilometre of roadway 7.6 centimetres thick and 12 meters wide. Crumb rubber usage varies proportionately with actual thickness, length or width.

Plus-Ride™ - The Plus-Ride™ proprietary system is a distinctly different method of rubber addition, using crumb rubber as part of the aggregate rather than as an integral part of this binder. Approximately 3 percent coarse crumb rubber (0.3 to 0.6 centimeter in size) is blended with specially-graded mineral aggregate to form a dense-graded rubber/aggregate mixture. Normal asphalt binder is then added to form the rubberized asphalt pavement mixture. In addition to the cost of crumb rubber, installed costs are increased by requirements of specially-graded aggregate and 1 to 1.5 percent extra asphalt binder. However, specialized installation equipment is not required. This system has also proven vulnerable to improper application in inclement weather, and field mix adjustments are different from standard asphalt. Approximately 56 tonnes of crumb rubber or 11 000 passenger tire equivalents are required per kilometre (7.6 centimetres thick, 12 meters wide).

BAS "Takallou" System - A recently developed non-proprietary variation of the Plus-Ride™ system is generally attributed to Dr. H. B. Takallou. It is very similar to Plus-Ride™, but uses two distinct crumb rubber particle size components (minus 10 mesh and minus 30 mesh) to achieve a denser aggregate gradation. Although the crumb rubber component is more expensive due to inclusion of finer material, the final void volume is reduced and highway performance theoretically improves. Since royalty payments associated with Plus-Ride™ are not required with this approach, total installed costs may be lower in spite of higher crumb rubber cost. Crumb rubber usage is also 56 tonnes per kilometre (7.6 centimeter thickness, 12 meter width).

UltraFine™ - Another non-proprietary method has been proposed recently by Rouse Rubber Industries. It uses "UltraFine" (minus 80 mesh) crumb rubber as a reactive additive to the asphalt binder. Five to ten percent fine crumb rubber is blended with the asphalt binder, then mixed with aggregate in standard percentages to form the asphalt paving material. By using fine particles, high reaction times and temperatures required in the "Arizona" system are decreased. Therefore, standard highway construction equipment and asphalt binder percentages are used. UltraFine™ has a cost 1.6 to 2.0 times greater than coarser crumb rubber used in other methods. However, lower UltraFine™ percentages, standard equipment, and the absence of licensing fees theoretically allow this system to be installed at the lowest premium cost versus standard asphalt. The system uses about 10 tonnes of crumb rubber per kilometre (7.6 centimetres thick and 12 meters wide). Although the tire usage per kilometre is lower, the total installed cost premium per tire equivalent may be equal to, or lower than the other alternatives.

Of these systems, the first two were developed more than 15 years ago and have been more widely applied. The latter two are relatively new techniques with experimental data just becoming available.

The performance results of rubberized asphalt using the "Arizona" and Plus-Ride™ systems have been mixed. While some states (Arizona, California, and parts of Texas) have reported excellent long-term results, apparently justifying higher initial cost, others (Minnesota, Wisconsin, Massachusetts, and others) have experienced disappointing results. The pavement either showed inadequate performance improvement to justify higher cost, or in some cases, failed prior to control sections of standard asphalt. These performance differences have been attributed to inherent failure of the rubberized asphalt technology, improper application methods, or improper testing location choice (depending primarily upon the perspective of the evaluator).

Both the Province of Ontario and Metro Toronto examined the use of rubber modified asphalt in 1977 to 1980 through research and test tract applications. Metro Toronto installed eight test sections. Although detailed long-term test data are limited, initial examination showed no cases of significant superiority that would justify rubberized asphalt's higher initial cost. In some cases, rubberized asphalt actually showed inferior performance versus standard asphalt. The Ontario Ministry of Transportation (MTO) has not been able to obtain any field performance data documented directly by state Departments of Transportation showing economically superior performance in applications exposed to hot summer temperatures and cold winter conditions such as those encountered in Ontario.

Due to the potential economic impact and the evolution of new techniques, MTO intends to conduct additional tests to evaluate installed costs and performance characteristics of applicable rubberized asphalt technologies under carefully controlled and documented Ontario conditions. One of the major concerns is the recyclability of rubberized asphalt mixtures and the ability to use recycled asphalt in their formulation. Four Wisconsin failures have been blamed on the use of recycled asphalt in the asphalt rubber system. Use of recycled asphalt requires mix design changes and alters field testing procedures, as does the use of rubberized asphalt. These adjustments that are necessary have not been thoroughly researched, and as a result, improper design and installation may have occurred. Thorough research may be required to effectively incorporate recycled asphalt into rubberized asphalt. In addition, the impact on air emissions from asphalt plants when rubber is added to the feedstocks has not been determined. Ontario's installed asphalt base represents a significant recyclable resource that could be transformed into a waste disposal problem if the addition of rubber renders it non-recyclable.

Preliminary estimates of the potential usage of scrap tires in asphalt used to pave Ontario roads are as follows. Assuming that MTO's test program yields satisfactory results, and a decision is made to pave virtually all of Ontario roads with rubberized asphalt, full-scale use of rubberized asphalt could begin in two to three years. For the first 15 to 20 years (that is, until all conventional asphalt was replaced), approximately nine million passenger tire equivalents per year could be consumed. The additional cost of using rubberized asphalt is estimated at just over $2.00 per passenger tire equivalent. It must be stressed that these are preliminary estimates only. Final cost and usage estimates will not be available until MTO's test program is complete.

The installed cost of rubberized asphalt versus standard asphalt varies widely depending upon the technology, quantity, location and equipment used. Documented test costs typically are two to three times higher for rubberized asphalt. In broader application, this cost differential can theoretically decrease to a 10 to 50 percent premium depending on technology and location. When related back to cost per tire as a management alternative, this cost differential is approximately $2.00 to $8.00 per tire.

3. Other Crumb Rubber Uses

There are many miscellaneous uses for crumb rubber, but most applications are small and offer limited growth. One exception is use as an additive or extender in plastics formulations. Millions of tonnes of plastics are sold each year in North America. Penetration of a significant market segment could potentially consume millions of scrap tire equivalents.

Development of crumb rubber usage in plastics is still in its infancy. Rubbermaid, one of the world's largest plastic products manufacturers, has publicly announced its intention to thoroughly examine the feasibility of incorporating recycled rubber and plastics into its product formulations. However, after almost three years of research, recycled rubber has not yet become part of any significant Rubbermaid product line. In addition, two companies (Rubber Research Elastomerics and R W Technologies), founded on the premise of providing formulated products for this industry, have failed to develop significant market penetration to date. The Rubber Research Elastomers (RRE) facility in Babbitt, Minnesota, constructed with $3.2 million of public bonds, loans and grants, was foreclosed. At the time of foreclosure, the plant was operating at less than 15 percent of announced capacity after three years of production and extensive market development efforts. R W Technologies has not established a commercial production plant.

The following factors affect crumb rubber penetration of plastics products markets:

1) Product Performance Characteristics - The performance properties of polypropylene and polyethylene decrease with addition of crumb rubber. Limited proprietary data indicates 10-30 percent decreases in tensile strength, elongation, flexural modulus, and Gardner test results upon significant addition of rubber. Therefore, expensive existing product molds would have to be changed, or product performance standards reduced, if crumb rubber formulations are used. Performance characteristics may be improved

by addition of wetting/bonding enhancement agents, but probably not enough to equal original standards. As a result, rubber modified plastics may be limited to specific market segments which do not demand high performance.

2) Compounding Costs - Many plastic products producers do not have existing compounding capability for blending rubber and plastics, so a compounded pellet must be purchased. Although there is a significant price differential between crumb rubber and plastic, the cost incentive may be decreased significantly by compounding costs, as illustrated in Table 25.

Table 25
COMPOUNDING COST IMPACT

	Cost ($/Kilogram)			
	Plastic ($1.10/kg)	**Rubber ($0.44/kg)**	**Compounding ($0.33/kg)**	**Total Cost ($/kilogram)**
Plastic	1.10	-	-	1.10
Plastic + 10% Rubber	0.99	0.05	0.33	1.37
Plastic + 30% Rubber	0.77	0.13	0.33	1.23
Masterbatch				
70% Rubber	0.33	0.31	0.33	0.97
Plastic + Masterbatch				
10% Rubber	0.95	0.14	-	1.09
30% Rubber	0.64	0.42	-	1.06

As shown in the above table, the cost of compounded plastic containing 10 to 30 percent crumb rubber is actually greater than un-blended plastic because of compounding costs. As an alternative, a blendable pellet (called a "masterbatch") can be compounded containing up to 70 percent crumb rubber. The masterbatch can then be mixed with plastic in a customer's operation to yield the desired crumb rubber concentration. This approach minimizes the total quantity which must be compounded, thereby reducing total compounding costs. Using this method, a masterbatch blend could be purchased at a savings of about 12 percent versus the plastic itself. When the masterbatch is mixed with plastic to achieve 10 to 30 percent final crumb rubber content, total formulated savings are only $0.01 to $0.04 per kilogram.

3) Alternative Waste Materials - Recycled plastics will potentially compete with crumb rubber as an extender. Depending upon type and quality, recycled plastics may be available at similar cost but not require compounding or significant loss of performance characteristics.

Crumb Rubber Market Development Priorities

In assessing potential Ontario crumb rubber markets, the probability of successfully developing significant crumb rubber usage will logically fall into a hierarchy from most to least probable as follows:

1) Displacement of U.S.-sourced crumb rubber purchases. Displacement can be accomplished by establishing crumb rubber capacity, quality, and competitive pricing within Ontario.

2) Displacement of other waste rubber materials in existing markets. Substitution of crumb rubber for buffings or single polymer waste rubber will require development expenditures and time to identify performance impact.

3) Development or expansion of new moulded product markets. New products or applications initially tailored around crumb rubber usage will require development, mould, and marketing expenses. Since most of these markets are comparatively small, crumb rubber usage per developmental dollar should be carefully assessed.

4) Development of major additive applications. Potential crumb rubber usage as an additive in asphalt and plastics is large, but realization of this potential will require properly structured long-term research and development programs to define technical and economic impact.

F. Summary and conclusions

With the introduction of Ontario's tire tax and the subsequent announcement that $16 million has been allocated for tire recycling projects there has been no shortage of proponents coming forward with proposals to solve Ontario's scrap tire management problem. During the course of the study virtually all of the proponents were interviewed. From the description of the main proponent's proposed projects, provided earlier in this chapter, it is clear that the proponents are very optimistic about their ability to process all of Ontario's scrap tires and then some. However, it must be noted that virtually all of the proponent's proposals are predicated on the availability of significant amounts of financial support, from the government of Ontario, for capital cost for processing facilities and product and market development.

While it is not the purpose here to comment on individual proposals, it is necessary to put the costs to develop the various processes, and their probability of success, in terms of the number of scrap tires they are likely to absorb, into perspective before policy options can be evaluated. The costs and prospects of the scrap tire processing technologies, in the order in which they appear on the management hierarchy are as follows.

Crumb Rubber in Consumer and Industrial Products

Crumb rubber processors can operate profitably at a tipping fee of $0.65 to 0.75 per scrap passenger tire received at their door. With landfill tipping fees in Ontario's major metropolitan areas ranging from $0.83 to 1.36 per passenger tire there would appear to be adequate financial incentives for crumb rubber processors to establish facilities. However, the major barrier to increasing usage of crumb rubber in products is the size of the market for such products. Simply stated, there are 200 to 250 million scrap tires generated annually in North America chasing consumer and industrial product markets that at best will be capable of absorbing less than 10 percent of them. As will be noted in the following chapter, recycling is the first choice for virtually all of the North American jurisdictions which have scrap tire management programs.

Based upon proposals submitted to OMOE, it would require public subsidies of about $6 million for the product and market development and $25 to 30 million in financial incentives to establish the processing and manufacturing facilities needed to aggressively pursue world markets for consumer and industrial products containing recycled tire rubber. This magnitude of expenditure would likely create sufficient processing capacity in Ontario to turn all of Ontario's scrap tires into crumb rubber. However, while there is considerable potential to displace crumb rubber that is currently imported from the United States and other waste rubber materials in existing products, there would be no assurance that world markets would expand fast enough or that Ontario producers would capture large enough shares of those markets to absorb the rest of the crumb rubber that could be produced in Ontario.

Rubberized Asphalt

If rubberized asphalt was used throughout Ontario, this application could absorb all of the scrap tires generated in Ontario. However, various proponents have been trying, for more than 20 years, to demonstrate the economic benefits of rubberized asphalt without notable success. Unless economic benefits can be demonstrated the additional cost of using rubberized asphalt will be about $2.00 per passenger tire equivalent on an ongoing basis. Given the rapid increase in the cost of alternative forms of scrap tire management rubberized asphalt could become a very attractive option if MTO's test program shows that there are no other disadvantages of using rubberized asphalt other than its cost.

Recovery of Raw Materials

Recovery of raw materials is also an application which could potentially absorb all of Ontario's scrap tires, but significant technical and economic hurdles must be overcome before recovery of raw materials from scrap radial tires becomes feasible. Reclaimed rubber cannot be used in new tires without unacceptable negative effects on tire safety and life. Pyrolysis can convert tires into oil, gas, and char. The oil and gas can be sold, but markets for the char have not been found. Without markets for the char, recovering the fuel value of tires through pyrolysis is not economically attractive.

Tire Derived Fuel

Tire derived fuel has the distinction of being the only application that is technically feasible, economically attractive without subsidies, and capable of absorbing all of Ontario's scrap tires in the short term. TDF's major shortcoming is that it is not high on the management hierarchy.

Conclusion

With the exception of a Toronto-area company that currently consumes up to three million scrap tires per year and a few other companies that process a relatively small number of scrap tires, a high percentage of the proponents of the various scrap tire processing technologies were either promoting concepts or start-up operations. While it is encouraging to see that the entrepreneurial spirit is alive and well in Ontario, these proponents face a very difficult task. Concepts and start-ups in general and those involving scrap tire recycling in particular have very low success rates, perhaps one in 10.

There are a number of Ontario rubber and plastics products manufacturers that have the research and development, manufacturing, and marketing capabilities needed to develop the products and markets necessary to increase the number of scrap tires that are used in consumer and industrial products. Many of these companies have yet to show an active interest in scrap tire recycling. The probability of OMOE achieving its scrap tire recycling objectives would be much improved if it actively sought out such firms and encouraged them to take advantage of the programs that OMOE offers to promote scrap tire recycling.

IV. SCRAP TIRE MANAGEMENT PROGRAMS IN OTHER JURISDICTIONS

A. Introduction

Establishing an effective scrap tire management program is a complex process due to interactions between diverse stakeholders including manufacturers, dealers, collectors, processors, product end users, environmental regulators, and enforcement agencies. In order to identify potential options for a scrap tire management program other jurisdictions were surveyed to determine how they were dealing with scrap tire management issues.

Scrap tire management practices and programs in the United States, Europe, and Japan are discussed in this chapter.

Ontario's scrap tire management program is discussed in detail in the next chapter.

B. Overview of U. S. state programs

State scrap tire regulations are evolving rapidly within the United States. A number of tire pile fires have increased awareness of the environmental hazards and potential public liability associated with uncontrolled tire stockpiling. The fires also demonstrated the ineffectiveness of historical solid waste regulations and enforcement in preventing pile formation. The shortage of landfill capacity and the trend to recycling wherever feasible also contributed to legislative and regulatory pressure for sound tire management programs.

In order to obtain a broad perspective, a survey of all U.S. state scrap management programs, compiled by Recycling Research, Inc., in February, 1990, was obtained. The survey shows a rapid increase in the number of state programs. The number of states with specific scrap tire regulations has increased from five in late 1988 to 22 as of January, 1990. In addition, measures to regulate proper disposal or recycling of tires will be presented to 17 state legislatures during 1990. Table 26 shows the progress of scrap tire legislation in each of the states.

The 22 states with active laws or regulations have chosen a wide variety of approaches to solving their tire problem. Major components of these tire programs are summarized in Table 27. Some of these states have established complete programs, while others have just begun the regulatory process by enacting legislation to provide a funding source for program development. In general, the development of scrap tire management programs has been an evolutionary process involving a series of steps, which typically include enabling legislation, initial regulations, corrective legislation, and detailed regulation, in a progressive sequence to further refine and adjust the system. While the need for some adjustment is inevitable, the magnitude and number of iterations can be minimized by careful analysis and application of previous experience.

TABLE 26

SCRAP TIRE LEGISLATION
STATUS REPORT, January 1990

(From Scrap Tire News, February 1990)

DRAFT - draft being written/bill in discussion
PROP - proposed/introduced in 1990 legislature
REGS - regulated under specific provision of solid waste or other laws
LAW - scrap tire law passed

STATE	DRAFT	PROP	REGS	LAW
ALABAMA	*			
ALASKA				
ARIZONA		*		
ARKANSAS				
CALIFORNIA				*
COLORADO			*	
CONNETICUT			*	
DELAWARE				
FLORIDA				*
GEORGIA		*		
HAWAII		*		
IDAHO				
ILLINOIS				*
INDIANA		*		
IOWA				*
KANSAS		*		
KENTUCKY		*		
LOUISIANA				*
MAIN				*
MARYLAND				*
MASSACHUSETTS			*	
MICHIGAN		*		
MINNESOTA				*
MISSISSIPPI				
MISSOURI		*		

STATE	DRAFT	PROP	REGS	LAW
MONTANA				
NEBRASKA		*		
NEVADA				
NEW HAMPSHIRE			*	
NEW JERSEY	*			
NEW MEXICO		*		
NEW YORK		*		
NORTH CAROLINA				*
NORTH DAKOTA				
OHIO			*	
OKLAHOMA				*
OREGON				*
PENNSYLVANIA		*		
RHODE ISLAND				*
SOUTH CAROLINA		*		
SOUTH DAKOTA	*			
TENNESSEE		*		
TEXAS			*	
UTAH		*		
VERMONT		*		
VIRGINIA				*
WASHINGTON				*
WISONSIN				*
WEST VIRGINIA		*		
WYOMING			*	

TABLE 27

WHAT THE LAWS CONTAIN

(From Scrap Tire News, February 1990)

STATE	FUNDING SOURCE	STORAGE REGS	PROCESSOR REGS	HAULER REGS	LANDFILL RESTRICTIONS	MARKET INCENTIVES
CALIFORNIA	$ .25/TIRE DISPOSAL FEE	*	*			*
COLORADO		*	*			
CONNETICUT		*				
FLORIDA	$1/TIRE RETAIL SALES	*	*	*	*	
ILLINOIS	$ .50/VEHICLE TITLE FEE	DRAFT	DRAFT	DRAFT	*	
IOWA					*	
LOUISIANA		*			*	
MASSACHUSETTS		DRAFT	DRAFT			
MAINE	$1/TIRE DISPOSAL FEE	*	*	DRAFT		
MARYLAND	STATE BUDGET APPROPRIATIONS	*	*	*		
MINNESOTA	$4/VEHICLE TITLE TRANSFER FEE	*	*	*	*	*
NEW HAMPSHIRE	GRADUATED VEHICLE REGISTRATION FEE (TOWN LEVEL)	*				
NORTH CAROLINA	1% SALES TAX ON NEW TIRES	*	*	*	*	
OHIO	DRAFT	DRAFT	*		*	
OKLAHOMA		*	*		*	
OREGON	$1/TIRE DISPOSAL TAX	*	*	*	*	$20/TON
RHODE ISLAND				*		
TEXAS	$ .50/TIRE DISPOSAL FEE	*				
VIRGINIA	$ .50/TIRE DISPOSAL FEE ON NEW TIRE SALES					
WASHINGTON	$1/YEAR ON VEHICLE REGISTRATION FEE	*	*	*		
WISCONSIN	$2/VEHICLE TITLE FEE	*	*	*	*	$20/TON
WYOMING		*	*			

C. Specific state tire programs

To identify specific program alternatives, eight of the twenty-two states with existing laws or regulations were selected for interviews and analysis. All five states with regulations predating 1989 (Minnesota, Oregon, Wisconsin, Florida, and Washington) were chosen to maximize practical experience, plus three others representing a cross-section of alternative approaches. Individual summaries of major program components are provided below.

1. Minnesota

Program Development

A law was passed in 1984 containing the following major provisions: (1) a ban on disposal of tires in landfills to promote tire recycling through elimination of low-cost disposal, maintain tire segregation, and increase landfill life; (2) enactment of a $4.00 increase in vehicle transfer fees to be placed into the Minnesota Motor Vehicle Transfer Fund for scrap tire management program development[7]; and (3) creation of programs for pile remediation and financial support for tire recyclers and processors. A series of additional laws and regulations have since been added including a new waste tire law that took effect in April, 1989 requiring tire dealers to accept a waste tire for each new one sold.

Revenue Source

The $4.00 vehicle transfer fee was chosen because state law prohibited a fee on vehicle registrations and tire tax collection was considered inefficient and difficult to enforce. The fee produces revenue equivalent to roughly $1.00 per scrap tire generated annually, and has proven to be an efficient mechanism.

Regulations

Minnesota has established detailed regulations requiring scrap tire processing operations to be licensed. The state has 3 fully permitted processing facilities and 5 provisionally permitted storage and transfer facilities, with 20 additional ones under review. Ninety transporter ID numbers have been issued. Haulers must submit quarterly reports containing data that allows the Minnesota Department of Transportation to track scrap tire flows.

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[7] Prices cited in this chapter are in 1990 U.S. dollars.

Pile Remediation

By late 1989 contracts for removal of 5.16 million tires have been issued at a cost to the state of $3.4 million. These contracts cover 64 percent of the known stockpiled tires. The goal for fiscal year 1990 includes clean-up of an additional 17 private piles containing 1.7 million tires at an estimated cost of $1.39 million and 25 county tire dumps containing 400,000 tires at a cost of $520,000. Pile removal is contracted through private operators and preference is given to those processing the tires for their materials or energy value. Most tires have been converted to TDF for use outside of the state, but a small portion was used by Rubber Research Elastomerics in crumb rubber production prior to their bankruptcy.

Other Programs

The state has additional flexibility to use grants to promote other tire related activities such as: (1) grants to counties of 50 percent (up to $30,000) of the cost to establish permanent transfer stations for efficient transportation; (2) market development grants to fund studies of TDF trials ($28,000) and rubberized asphalt bicycle trail construction ($30,000); and (3) public education through publishing a free quarterly newsletter called "Tire Tracks".

The state is considering rule modifications which would allow grants of up to $30,000 (75 percent of total cost) for technical or economic applications feasibility studies and low interest loans (5 percent below treasury rate) of up to 90 percent of the capital cost ($1.5 million maximum) of facilities using tire-derived products.

Funds Disbursements

Fiscal year 1990 (ends June 30) expenditures of $3,262,750 are projected as follows: program administration, $493,500; tire dump clean-ups, $1,917,250; loans, $762,000; grants $90,000.

Strengths

An effective program of controlling illegal tire stockpiles has evolved. A private tire processing network serving the state has developed. A substantial portion of tire piles has been removed. Revenue collection has been efficient without enforcement problems.

Weaknesses

The landfill ban prior to development of tire processing facilities created legal tire piles requiring higher public removal expense than equivalent direct processing costs. Government financial support of a crumb rubber processor through loans, grants, and industrial revenue bonds resulted in a $3-4 million loss upon the company's failure to meet projected market volumes. Markets for tire products (crumb rubber, TDF, etc.) within the state are still clearly inadequate for generated volumes.

Results

Most tires have been converted into TDF for use outside of the state, but internal TDF customers are pursuing combustion permit modifications. One TDF producer is developing crumb rubber production capacity to serve local demand and enhance product value.

2. Oregon

Program Development

Oregon initiated a ban on whole-tire landfilling and stockpiling in the early 1970s, effectively establishing a basis for scrap tire processing by local companies. Even though enforcement became progressively weaker, large tire piles were generally avoided. A revised, comprehensive state law passed in 1987 provided the basis for current regulations, with implementation beginning in January, 1988.

Revenue Source

One dollar per tire is collected by the dealer on all new replacement tires sold (not on new cars). Although a vehicle registration fee was preferred, the state constitution limits such revenue to direct highway use. Dealers receives $0.15 per tire to cover collection and reporting costs. The state Department of Revenue is responsible for collections. Dealers must attain a certificate authorizing them to collect this fee. This step was instituted to overcome initial difficulty in identifying tire dealers. There was no existing revenue collection network in place since the state does not have a sales tax. Additional part-time revenue investigators are being hired to increase compliance.

Regulations

There are detailed licensing requirements for haulers, processors and storage facilities. Commercial haulers are charged a $25 application fee and $175 per year per vehicle, and must post a $5,000 assurance bond. Private haulers (own tires only) pay a $25 application fee and $25 per year, but may register only one vehicle. Ninety-six tire carriers have been permitted. Noncompliance is subject to civil penalties, but criminal penalties are being considered because of difficulty in collecting penalties due to absence of assets. Processors and storage facilities must be licensed and post a $1.00 per tire bond (standard Oregon form to avoid collection problems) or a corporate guarantee for the maximum number of stored tires. The bond is intended to cover removal costs in the event of business failure or desertion. The dealers are not currently required to keep disposal records (now being changed), but the state has legal recourse for improper disposal. All tires must be chipped prior to landfilling. Eighteen landfill operators have modified their solid waste permits to allow temporary tire storage until they can contract for collection services or install shredders.

Pile Remediation

The state did not have many piles, but provided a toll free number for resident reporting. Oregon negotiates a compliance schedule with existing pile owners, and pursues known generators. Seven piles (200,000 tires) have been removed at a cost of $170,000 to the state and 92 others (270,000 tires) have been voluntarily removed without public funds.

Other Programs

The state provides subsidies of $20 per ton to enhance market development for waste tires or chips, including use as a fuel. The subsidy is paid directly to the fuel user once he has obtained and demonstrated compliance with all applicable state air and water pollution control regulations and obtained a certificate from the tire processor assuring that the chips were produced from Oregon-sourced tires.

This subsidy has resulted in increased interest in pursuing extensive testing required for TDF usage by both cement and paper companies, as well as increasing economic justification for adding pollution control equipment if necessary. Two paper companies and one cement kiln burn TDF in compliance with rigorous standards, and others are in advanced permitting stages.

The state has flexibility to increase support levels above $20/ton, (up to $100,000 per project) for other demonstration recycling projects, such as rubberized asphalt. The supports have also initiated creative examination of using chips to replace other materials (such as roadbeds) which would otherwise be economically unattractive.

Strengths

Strong licensing and financial assurance programs have minimized pile formation and public liability. Market subsidies have enhanced regional TDF market development, with Oregon tires even being burned in a California cement kiln. Subsidy flexibility can enhance alternative demonstration projects.

Weaknesses

Some inefficiency in fee collection and enforcement due to absence of a pre-existing sales tax collection network. Absence of criminal penalties has increased the rate of non-compliance. Additional measures are required to promote rural transfer sites which are not adequately served by the private sector.

Results

It has been estimated that over 50 percent of Oregon scrap tires are used as fuel, 25 percent shredded and land filled, and 25 percent are taken to neighbouring states with more lenient, lower-cost tire disposal regulations. One Pyrolysis system operates only sporadically due to the absence of a char market. Small quantities are converted to crumb rubber for regional use in Plus-Ride™ rubberized asphalt installations.

3. Washington

Program Development

In 1985, the legislature established a Vehicle Tire Recycling Account funded by a 0.12 percent tax levied on the value of new vehicle tires sold by dealers. It also directed the State Department of Ecology to establish programs to encourage proper disposal and for pile removal. Lack of adequate funds prevented appropriations being made to hire a coordinator until November, 1987. Since then, the state has been collecting background information and has developed carrier/storage regulations which took effect April 1, 1989, but inadequate funding has prevented further progress. Funding was increased through initiation of a $1.00 per new tire fee to be collected by dealers, effective October 1, 1989. Program emphasis is on preventing landfilling of whole tires, even at the expense of building large controlled stockpiles.

Revenue Source

The original 0.12 percent tax failed to raise projected funds because of inadequate local enforcement. When modified, the state preferred the vehicle registration fee method but was precluded from doing so by state constitutional provisions. Under the new law, $0.88 per tire accrues to the Tire Recycling Account, while $0.10 is rebated to dealers and $0.02 to state revenue agencies to cover collection costs. Since the state constitution and regulations place enforcement responsibility on counties, collection efficiency depends upon local efforts and has been about 60 percent effective.

Regulations

Haulers are required to pay $250/year for a tire carrier license and must document delivery points for scrap tires. Landfilling of whole tires is prohibited, but stockpiling at permitted sites is allowed under regulated conditions, including local permit approval, $100,000 assurance bond, and reporting criteria. Illegal disposal is subject to civil penalties of $200-2000 per offense. Dealers must use licensed carriers or face similar penalties.

Pile Remediation

The state is initiating pile clean-up efforts and is considering a stair-step bidding process for removal contracts which would favour reuse and recycling. For instance, a contractor quoting $1.00 per tire to convert tires into muffler hangers likely would be chosen in preference to an alternative bid of $0.50 per tire to shred and landfill.

Other Programs

The state constitution prohibits direct grants or subsidies to private industry, so the state is considering establishing contracts for disposal services at costs fixed by a bidding process with preference for recycling methods.

Strengths

The stair-step preference for recycling oriented contractors is an interesting concept, but possible higher cost may decrease the rate at which piles are removed.

Weaknesses

Large stockpiles of tires generated in Washington and neighbouring states are being accumulated through the landfill ban and availability of low cost stockpile sites. These piles may become a future public liability. Processing and market development is not being enhanced by low cost stockpiling or demonstration funding. Fee collection efficiency is comparatively low because of variable local enforcement.

Results

The current policy is encouraging large stockpile formation with low tipping fees. Alternative tire processors are discouraged from market entry by these low tipping fees.

4. Florida

Program Development

A scrap tire law was enacted in 1988 with specific provisions for funding mechanisms, processor permits, hauler registration and fund allocations and scheduled for progressive implementation during 1989. The program focuses state-level activity on revenue collection, applications research and development, and tire pile abatement, while counties receive up to 70 percent of total available resources (apportioned by population) for locally administered scrap tire management programs. The program is comprehensive and encourages local solutions and implementation.

Revenue Source

An initial fee of $0.50 per tire was levied on all new tires sold in the state (including those on new cars) effective July 1, 1989, rising to $1.00 per tire on January 1, 1990. The State Department of Revenue receives three percent for administrative costs and has encountered little implementation difficulty due to existing detailed business coding, auditing, and enforcement systems associated with state sales tax collection. Tire sellers have been readily identified and educated on the details of the program by direct mail which has resulted in high compliance. A vehicle registration fee increase was carefully considered, but was not chosen due to the high percentage of tourist vehicles and trucks not registered in Florida. All net funds are deposited in a tire trust fund for use exclusively in the scrap tire management program, which enhanced dealer acceptance and compliance.

Regulations

Major components include the following:

(1) Pile site owners were required to notify the Department of Environmental Regulation of their existence by April 1, 1989, then obtain a permit, relocate to a permitted facility or cease operations under a closure permit by July 1, 1989.

(2) Processing facilities, solid waste management facilities, collection centres, and mobile shredder operators were required to submit permit applications or modifications by May 23, 1989. As of January 1990, 15 mobile shredder operators had applied for or received permits and one permanent processing facility had been permitted with another under review.

(3) Scrap tire collectors had to register by July 1, 1989 and must keep records and submit a summary report once per year. As of January 1990, 370 waste tire hauling/collection companies had registered 900 trucks.

(4) Tire dealers are required to use a registered hauler but do not have to maintain or submit records.

(5) Tires must be shredded into at least eight pieces prior to landfilling as of July 1, 1989.

Enforcement Penalties

Any party not complying with the regulations is subject to fines of $10,000 per day under state law. Although the severity of this penalty should enhance compliance, it actually impedes legal enforcement in some cases because it is generally contested and, therefore, requires extensive case preparation time and demonstration that the severity of the punishment fits the crime.

Dade County (Miami area) has established its own regulations, providing standard fees for small violators, which are easier to prosecute. However, dumping of commercial quantities (over 500 pounds or discharging from a commercial vehicle) is a third degree felony punishable by vehicle confiscation, fines, and imprisonment. It is enforced with vigour by any enforcement agency (from highway patrol to fish and game agencies) because it is recorded as a felony arrest initiative. It was instituted to control extensive dumping in the Everglades.

Other Programs

The law allows the state or counties to implement grants for the following purposes: constructing, operating, or contracting for processing facilities; processing services contracts; removal or contracting for removal of piles; research; establishing or operating collection centres; and providing incentives for establishing private collection centres.

Revenue Disbursements

The existing law provides the state with latitude in fund disbursement by specifying only maximum disbursement percentages which total more than 100 percent, allowing priorities to shift as necessary. The following maximum percentages apply under current law: 3 percent for administration, 10 percent for research and development, 40 percent for tire site abatement, and 70 percent for county grants. Since these percentages total 123 percent, obviously not all of the programs will be funded at their maximum level in any given year.

Abatement may be fully funded initially at the expense of lower county grants, but county grants will increase as abatement activities are completed.

Applications Development

Although the state does not provide direct market incentive grants or payments, research grants have been, or are being, used to examine alternative uses such as highway asphalt application trials, daily landfill cover, drainage media in septic fields, and chip leachability for other construction purposes. Although the omnibus recycling law dictating a 30 percent reduction in landfill quantity does not count combustion as a recycling application, TDF is currently being burned in waste-to-energy facilities in Palm Beach and Pinellas counties. Florida Crushed Stone has requested a permit for TDF combustion in a kiln. Florida law provides an exemption from state sales tax for waste fuels, including TDF, burned in boilers.

Strengths

The program combines state strengths in revenue collection and administrative direction with local county-wide control of specific plans.

Weaknesses

The very strength may also be the most glaring weakness if fragmented county programs are developed which fail to coordinate efforts to achieve volume efficiencies. The ability to impose lower fines would enhance enforcement.

Results

Most tires are currently being shredded and landfilled in monofills (tire shreds only) for "future recovery". However, some shreds are being used as daily landfill cover and other creative uses are being explored. A comprehensive evaluation of rubberized asphalt performance and cost has been initiated.

5. Wisconsin

Program Development

In 1987, the Assembly passed a bill establishing a $2.00 vehicle title fee effective May 1, 1988. In September 1989, the Department of Natural Resources, (DNR), published rules for future expenditure of funds to implement its waste tire removal and recovery program.

Revenue Source

The $2.00 annual vehicle registration fee was chosen because of its ease of collection and enforcement.

Revenue Disbursements

The proposed expenditure of the $3.3 million raised annually is as follows: $2 million for clean-up of the estimated 20 million stockpiled tires at a rate of 2.0-2.5 million tires per year; $0.75 million to reimburse end users recovering energy or product value at a rate of $0.01 per pound of use as a market development incentive; $0.25 million for grants to investigate development of new waste tire applications; and $0.30 million for administration.

Regulations

Under a 2 year trial ending in July, 1991, haulers and processing facilities are required to be licensed and dealers are required to use licensed haulers and processing facilities.

Enforcement

The regulations fail to specify penalties for non-compliance, so enforcement has been difficult.

Pile Remediation

Over 1.0 million stockpiled tires had been removed as of January, 1990 at an approximate cost to the state of $0.6 million. A second contract for clean-up of 1.5 million tires has been awarded for $1.0 million and is scheduled for completion by July, 1990. Contractors are chosen using criteria which favour tire product application over contract price.

Other Programs

The state has funded waste tire reuse evaluations as a method of examining and promoting environmentally sound applications. Examples include: (1) air emissions testing ($50,000) of TDF supplemental fuel use at Nekoosa Paper; (2) testing leaching characteristics of tires ($50,000) for use as a core in earth covered highway embankment projects and construction of an experimental noise berm using this design (no cost estimate); (3) initiation of a 2 year DOT/University of Wisconsin program to establish criteria for tire chip use as a sub-grade fill ($50,000 from fund plus $105,000 from DOT); (4) two additional combustion evaluations of an industrial boiler and municipal waste incinerator; and (5) a fifth rubberized asphalt trial section funded by DOT which will not utilize recycled asphalt in the mix. (Four previous tests failed before the control, possibly due to inclusion of recycled asphalt).

Strengths

The program provides for efficient fee collection and administration; effective market development grants to evaluate major applications and market subsidies to encourage market actualization; and active removal of tire stockpiles.

Weaknesses

Absence of non-compliance penalties and enforcement impairs effectiveness of licensing provisions. Methods of assuring that market incentives are provided only on Wisconsin-generated tires are still evolving.

Results

Although the program is relatively new, most tires are being shredded for fuel use and new TDF customers are being developed. In addition, sound environmental combustion data is being obtained and new chip applications and highway use are being examined.

6. Virginia

Program Development

A scrap tire bill, passed in 1989, provided a scrap tire program revenue source, established a Used Tire Management Advisory Committee and directed the committee and the State Department of Waste Management to draft a scrap tire management plan including a state subsidized TDF test burn in combination with coal, and development of a network of tire collection centres.

Revenue Source

The bill established a $0.50 per tire disposal fee on new tire sales effective January 1, 1990 to be deposited into a dedicated Waste Tire Fund. Collection and enforcement are to be handled by the state tax department with reimbursement of its costs from revenue. Revenue is expected to exceed $2 million per year based on an estimated 5 million annual tire sales through 5,000 dealers.

Regulations

Regulations will be developed and implemented when markets have been developed for products derived from scrap tires from current tire generation and existing piles.

Pile Remediation

No current efforts to remediate piles are underway. Virginia may have 25 to 50 million tires in possibly 400 piles with the largest one containing 5 to 7 million tires. Satellite imaging is being used to identify piles.

Other Programs

The state believes that the key to an effective tire management program is product market development. Current efforts have been focused on TDF trial demonstration (environmental impact assessment) and accelerated market development because of the large, rapidly accessible market within the state. If initial trials are positive, it is hoped that coordinated efforts by environmental regulatory agencies and waste management groups will allow accelerated permitting procedures for potential TDF users. The state is evaluating market subsidies to further encourage rapid market development. The state will consider siting processors at state prisons and using inmates to construct the facility to accelerate processor siting and permitting.

Strengths

Recognition of the importance of market development is a critical first step in establishing an efficient tire management program.

Weaknesses

Market development delays could result in additional pile formation in the absence of interim hauling and storage regulations.

Results

Tires are continuing to be landfilled and stockpiled until regulations are complete and markets have been developed.

7. Maine

Program Development

Maine chose to enhance its scrap tire management program through additions, which were enacted in 1989, to its general solid waste management regulations. Applicable sections established a scrap tire revenue source, initial licensing requirements, and transporter manifest requirements. Detailed rules are currently being written. Only basic components have been established to date.

Revenue Source

Maine implemented a $1.00 per tire advance disposal fee on sale of new tires, effective January 1, 1990, to fund pile clean-up and recycling grant/loan programs. The Bureau of Taxation will collect and enforce the tax, with reimbursement of costs estimated at 11-15 percent of revenue. The net revenue is deposited in a Maine Waste Management Fund along with other fees on appliances, batteries, and special wastes.

Regulations

Tire processing and storage facilities must be licensed and demonstrate compliance with requirements for groundwater protection, fire protection, buffer zones, and financial assurance. Proposed transporter rules would require declarations on a manifest of the generator, quantity and type of scrap tires and the disposal facility.

Pile Remediation

The state has taken legal action against owners of two large piles to prevent further acceptance of out-of-state tires. Pile remediation efforts will be limited until the suits are settled or until adequate funds are available.

Other Programs

The legislature also mandated funding of an asphalt rubber program to be conducted by the Maine Department of Transportation in 1990. The legislature advanced $1.3 million for initiation of special solid waste programs and staffing which must be reimbursed from collected funds. The law provides for reduced site permitting procedures for fuel substitution at existing facilities.

Strengths

Legislative guidelines for scrap tire storage, processors, and transporters are comprehensive, but effectiveness will depend upon actual detailed rules and implementation procedures which are still being developed.

Weaknesses

Revenue collection is inefficient due to the collection mechanism and potential dilution by becoming part of a general special waste fund.

Results

Tires are still being landfilled and stockpiled pending full development of regulations. One TDF customer has completed environmental testing and is using TDF under an interim approval.

8. California

Program Development

California passed a comprehensive scrap tire law (AB 1843) in September 1989 which included the following components: a revenue generation mechanism and dedicated tire management fund; transport, storage, and processing regulatory guidelines and civil non-compliance penalties; designation of regional landfills for shredded tire storage in segregated cells; loans and grants to tire processors; and an objective of decreasing landfill disposal and storage by 25 percent, within four years of full implementation, through maximum recycling.

Revenue Source

Effective July 1, 1990, a $0.25 fee is to be collected by the dealer for each tire left with him for disposal. The dealer retains 10 percent for cost reimbursement and submits the remainder for deposit in the dedicated California Tire Recycling Management Fund. The California Waste Management Board is responsible for collection and enforcement, and may deduct up to 3 percent to cover costs.

Regulations

Regulatory guidelines cover: registration statements and annual reports from any party maintaining a tire inventory of over 500 tires; permit regulations for major (more than 3,000 tires) and minor (less than or equal to 3,000 tires) scrap tire facilities that include fire prevention, security, vector control, size and height limits, financial assurance, closure plans, and enforcement penalties; and illegal dumping penalties.

Tire Remediation

The law enables the state to undertake pile remediation if the responsible party fails to act, and to take subsequent legal action to recover costs.

Other Programs

The Board is empowered to promote scrap tire recycling through direct loans, subsidies or grants for: private or public entities engaged in activities reducing landfill disposal; technical or applications research to reduce landfill disposal; recycling program planning and implementation; businesses which shred tires for recycling; information and education programs; and direct purchase of shredders at dedicated facilities.

In addition, the law directs the Board to submit a report on the feasibility and environmental impact of using scrap tires as a supplement fuel in kilns and other industrial processes before December 1, 1991, including recommendations, if appropriate, for encouraging greater utilization as a fuel.

Funds Disbursements

California advanced a $1 million loan to the fund to implement the bill, with repayment to be made from revenue by June 1991. Anticipated annual revenue is $7 million per year.

Strengths

The law provides comprehensive guidelines for regulatory development, but effectiveness will depend upon detailed regulations and enforcement procedures.

Weaknesses

Revenue collection may be extremely difficult to implement and enforce and may encourage individuals to dispose of tires with household trash rather than paying a fee to leave them with dealers. Dealers may even encourage this since their disposal costs are greater than the $0.025 they keep. The incentive to dispose of scrap tires with household waste will become even greater if the fee is increased in the future.

Results

Although the basic regulations are generally sound, results will probably be hampered by limited funds because the funding mechanism is un-enforceable and counter-productive.

D. U.S. national scrap tire bill

On February 12, 1990 H.R. 4147 a bill known as the Tire Recycling Incentives Act was introduced in the U.S. House of Representatives.[8] The bill, introduced by Representative Esteban E. Torres of California, would require tire manufacturers and importers to begin recycling tires and file annual reports of their recycling activities with the Environmental

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[8] The description of H.R. 4147 is summarized from an article in the March/April edition of *Scrap Tire News*.

Protection Agency (EPA) within two years of the bill's passage. The main provision of the bill is a system of credits designed to ensure that a certain percentage of scrap tires are retreaded, recycled or otherwise re-used. The recycling rate would be determined by a percentage of annual tire production, and would increase 5 percent per year for 10 years.

Under the bill a system would be established to create credits for scrap tire recycling and for tire manufacturers and importers to purchase recycling credits from recyclers.

Recycling credits would be allocated as follows:

- one-fourth credit for shredding one tire,
- one-fourth credit for burning a shredded tire,
- one-half credit for burning one whole tire in "an approved manner",
- three-fourths credit for re-using or recycling a shredded tire, and
- one credit for re-using or recycling one whole tire.

The EPA would have the authority to name other approved recycling methods.

Other provisions of the bill include:

- Tire dealers and scrap tire collectors would be required to keep, for at least three years, receipts from scrap tire haulers showing the date, number of tires hauled, and the hauler's identification number.
- Within 18 months of the bill's passage the EPA Administrator would set requirements for states programs that would include provisions for collection, transportation, storage, financial assurance, and management of scrap tires.
- One year after passage of the bill, whole tires would be banned from landfills. Shredded tires would only be allowed in monofills.

The fate of H.R. 4147 is uncertain. However, the bill's sponsors are considering other avenues to keep the measures proposed on the bill alive.

What distinguishes H.R.4147 from other legislated scrap tire management programs is that it puts the onus for scrap tire management on tire manufacturers and importers. The more common approach, including Ontario's, is to impose some form of tire tax, and to use the revenues from the tax to fund scrap tire management programs. By imposing a tire tax that is earmarked for scrap tire management programs the jurisdictions effectively assume the responsibility for scrap tire management. Regardless of who has responsibility for scrap tire management the fundamental problems that must be dealt with remain the same; namely: a growing shortage of legal disposal options for scrap tires and limited markets for products and materials derived from scrap tires.

E. European scrap tire management practices

Scrap tires do not appear to be a high priority with European environmental authorities throughout Europe. As of early 1990 none of the European countries had comprehensive scrap tire management programs. However, three countries: the United Kingdom, Germany, and The Netherlands are studying the issue and are expected to propose comprehensive recycling programs in the near future.

Summaries of scrap tire management programs in a number of European Countries are presented below. The summaries are drawn from the article *Scrap Tyre Report* which appeared in the April, 1990 edition of European Rubber Journal. Much of the information on individual countries is from a 1988 survey carried out by Bipaver, the international federation of national associations of tire specialists and retreaders.

1. Austria

Scrap tires per annum: 44 to 46 000 tonnes

National regulations: None, although scrap tires are defined as special refuse and must be registered by quantity. They cannot be deposited at ordinary refuse sites.

Current means of disposal: Incineration by cement industry.

Future proposals: Maintain current procedures.

Action by the national tire association:
- Preparation of a national model for tire disposal.
- Initiation and continuation of talks with authorities, cement industry and other businesses to establish regional collection sites.

2. Switzerland

Scrap tires per annum: 58 000 tonnes

National regulations: No federal regulations. Some states regulate landfill disposal with fees at source, with landfill dumping prohibited by some municipalities.

Current means of disposal:
- Landfill,
- Incineration by the cement industry,
- Added as granules or powder to building materials.

Future proposals: Promotion of incineration by the cement industry and as a filler in asphalt.

Action by the national tire association:
- Study of scrap tire disposal undertaken in 1979 -- still regarded as valid.
- Study with federal authorities on the use of rubber in asphalt. Results expected 1990.

3. West Germany

Scrap tires per annum: 350 000 tonnes

National regulations: Tires not to be moved with normal refuse.

Current means of disposal:
- 37 percent incineration by the cement industry.
- 30 percent landfills and tire piles.
- 20 percent retread.
- 11 percent exported.
- two percent other (physical) uses.

Future proposals:
- Incineration plants planned.
- Development of new recycling methods.
- Possibility of use in road construction.

Action by the national tire association: Contact with ministry of the environment and firms capable of using scrap tires.

4. Denmark

Scrap tires per annum: 76 000 tonnes

National regulations: None.

Current disposal: Incineration by the cement industry.

Future proposals: Tires to be granulated.

Action by national tire association: Negotiations with the Department of the Environment.

5. France

Scrap tires per annum: 240 000 tonnes

National regulations: Burning or dumping in public places prohibited.

Current disposal: Very expensive to dispose of tires.

Future proposals: Creation of incineration units.

Action by national tire association: Little has been done.

6. United Kingdom

Scrap tires per annum: 292 000 tonnes

National regulations: No specific regulations. Tires are not regarded as controlled waste although they should be dumped only at licensed sites. It is recommended that tires should be shredded and not make up more than 5 percent by volume of landfill materials.

Current means of disposal:
- 36 percent landfill.
- 29 percent left in scrap yards.
- 21 percent incinerated.
- eight percent exported.
- four percent incinerated in cement kilns.
- two percent other (physical) uses.

Future proposals:

- Privatization of electricity generating boards may stimulate use as a fuel.
- Use in roads may show a slow increase.

Action by the national tire association: All relevant bodies are willing to help channel scrap tires through the distribution chain, provided clearly defined disposal methods are agreed.

7. Italy

Scrap tires per annum: 150 000 tonnes

National regulations: Scrap tires are defined as urban waste. They are the responsibility of local authorities.

Current disposal:

- Disposal in controlled places.
- Shredding and incineration.

Future proposals: Incineration for energy production.

Action by national tire association: Cooperation with public authorities.

8. Norway

Scrap tires per annum: 26 000 tonnes

National regulations: None.

Current disposal: Dumping.

Future proposals: Government restrictions expected.

Action by national tire association: Attempts to involve government in a mutual solution.

9. Sweden

Scrap tires per annum: 50 000 tonnes

National regulations: None.

Current disposal: Ten percent of tires retreaded.

Future proposals:
- Investigation of recycling methods.
- Consideration of finance for tire collection.

Action by national tire association: Not specified.

10. Finland

Scrap tires per annum: 30 000 tonnes

National regulations: No mention of tires in environmental legislation, although some local dumping regulations in place.

Current means of disposal:
- Dumping,
- Some tires undergo pyrolysis,
- Experimental use in road surfaces.

Future proposals:
- Research into pyrolysis.
- Use in road surfaces desirable, but unlikely in the short term.

Action by the national tire association: Represented on committee appointed by the Department of the Environment.

F. Japan

The Japanese Automobile Tire Manufacturers Association (JATMA) estimates the following scrap tire usage: retreading, 12 percent; export, 17 percent, reclaim and crumb rubber, 22 percent, fuel usage, 35 percent; other uses, 3 percent; and landfill/abandoned, 11 percent. Much of the reclaim and crumb rubber is apparently exported to other countries in the region as a low-cost substitute for virgin rubber. In all countries it appears that scrap tire usage has developed as a result of specific industrial initiatives rather than well-defined government programs.

G. Summary

Comprehensive scrap tire management programs are either non-existent or in the early stages of development in most countries. A review of scrap tire management practices in European countries revealed a number of scrap tire applications, but a general absence of comprehensive national scrap tire management programs. Extensive use is made of scrap tires as a cement kiln fuel in Germany, Switzerland, Austria, Denmark, the United Kingdom, and Japan with some usage in Greece, Spain, and Mexico. Dedicated whole tire combustion units exist in Germany, Italy and the United States, with a new, larger facility currently in the final development stages in England. Small crumb rubber production facilities exist in the Netherlands, France, Germany, Sweden, Japan, and the United States.

A number of U.S. states have initiated scrap tire management programs, and their experience may offer some guidance for jurisdictions that are in the process of developing scrap tire management programs.

Various funding mechanisms have been utilized to generate revenue required for establishing and maintaining tire management programs. Although vehicle registration fee increases offer the advantage of optimum collection efficiency, a fee based upon sale of new tires is a feasible alternative when there is a pre-existing sales tax collection and enforcement mechanism in place. Ontario's tire tax is considerably higher than similar levies in U.S. states, but it provides resources for development and support of a sound program.

One major objective of tire programs is generally prevention of uncontrolled tire stockpiles that become public liabilities. Requiring registration of haulers, processors, and all disposal sites provides a mechanism for scrap tire control. Control is enhanced by requiring records to be maintained, manifests, and/or performance bonds to ensure regulatory compliance. Regulating stockpile size, site conditions, and bonding requirements have proven to be additional desirable measures which decrease the economic advantage of stockpiling while controlling potential public liability.

The most effective programs have provided and encouraged a variety of tire management alternatives. Elimination of landfilling prior to the creation of other alternatives has enhanced development of alternatives, but led to massive stockpiling (and potential liability) in the interim period as processing facilities are being developed. Requiring shredding prior to landfilling reduces volume, while the resulting increased disposal cost encourages other management methods. Effective programs have recognized the product markets as a key to the tire management solution and have encouraged their development through research and/or market support initiatives. Successful programs include a variety of market uses for scrap tires including materials recovery, energy, and use in various structures. Higher value uses can be encouraged with tiered market support initiatives if inherent, market incentives prove to be inadequate.

V. POLICY ANALYSIS

A. Introduction

In response to Ontario's growing municipal solid waste (MSW) disposal problems, OMOE established a target of diverting 25 percent of Ontario's MSW from disposal to alternative uses, by 1992 and 50 percent by 2000. Scrap tires constitute a visible and important part of the province's MSW disposal problem. As Chapter II has shown, the majority of Ontario's scrap tires are landfilled or stored in tire piles. Landfilling tires whole consumes disproportionate amounts of increasingly scarce disposal resources and creates landfill engineering problems. Landfilling tires shredded or whole with other MSW repudiates the scrap tire's value as a productive resource by rendering it unavailable for subsequent use. The primary policy challenge facing OMOE is how to decrease scrap tire generation and promote the diversion of scrap tires from disposal to productive use.[9]

When tires have been denied or discouraged access to landfill, by direct ban or by tipping fees, the result has normally been their diversion to tire piles. In theory this has preserved the tires for subsequent use. The practice has been somewhat different. The piles have seldom found their way into productive use, and instead have imposed a direct or indirect public burden, as an eyesore, a breeding ground for insects and -- as spectacularly demonstrated at Hagersville -- a fire hazard in waiting and drain on the public purse. Thus a second policy challenge for OMOE pertains directly to scrap tire pile management: under what conditions should scrap tire piles be permitted to accumulate?

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[9] "Productive use" is employed throughout this chapter to refer to reuse, recycling and energy recovery.

Finally in the immediate post-Hagersville period, there is a third policy challenge. In the aftermath of the fire and the governmental response to it, there has been a sharp decrease in the flow of scrap tires to piles. The collection network has ceased to function in a number of areas, leaving generators to find legitimate outlets on their own. This is a particular problem for those jurisdictions in which the landfill has refused to take tires, since the generator is without a legal local alternative. OMOE must decide what action to take in response to this situation.

This chapter addresses three interconnected policy issues. Section B reviews some of the key factors underlying and conditioning these policy deliberations and discusses criteria which may be applied to the selection of options for dealing with these issues. Section C describes the policy initiatives which the Ontario government has undertaken to date. Section D discusses options for using the trend to increasing disposal costs to encourage diversion from disposal. Section E outlines the options for directly encouraging increased productive use of tires. Section F discusses pile management.

B. Factors and Criteria for Policy Assessment

1. Factors Underlying Policy Considerations

To be effective in pursuing the primary goal of diverting scrap tires to productive use it is important to recognize the fundamental reality underlying the conditions described in Chapters II and III: scrap tire flow is determined by the relative economic attractiveness of the alternatives available, as conditioned by the established regulatory framework.

Accordingly, there are two sets of levers available to encourage alternatives to disposal:

- decreasing the attractiveness of the disposal options so that generators and others seek out alternatives to disposal, and
- directly increasing the attractiveness of scrap tire reduction and productive use options, so that generators are drawn to these solutions.

The factors described in this section highlight some of the main conclusions drawn from the previous chapters. They set the framework within which the OMOE may choose its set of initiatives to work these two levers.

Trends in Disposal Costs

An adequate supply of tires at a suitable price is essential for their productive use. In cases where scrap tires cannot be sold for direct re-use or retreaded the price is negative. That is, the recycler must be able to charge scrap tire generators to take them. The availability of cheap disposal has played a major role in preventing this in the past. The current trend to increasing disposal costs provides the clearest and most powerful incentive to a reversal of the current pattern of scrap tire disposal. However, without suitable policy support, this powerful stimulus could be reduced. Because of its provincial authority, the OMOE is in a unique position to ensure that this does not occur.

Table 28 summarizes the current quantities of scrap tires being landfilled and the range of tipping fees charged, across the province, by region. Landfill tipping fees have increased significantly in many parts of the province over the last decade, as municipalities with scarce and costly disposal resources have sought to extend their lifetimes and finance current activities and future acquisitions. This is likely to continue. So too may the trend to ban landfilling of whole tires.

Future tipping fee increases may result from municipal initiative or from provincial government leadership. In either case it is important to understand the dynamics of the increase, because unless supported by other initiatives, these increases may not stimulate productive use.

Table 28

Scrap Tires Landfilled and Landfill Tipping Fees by Region: 1989

(Passenger tire equivalents)

REGION	QUANTITY OF SCRAP TIRES	PERCENTAGE LANDFILLED	TIPPING FEE PER TIRE RANGE
Central	5 939 400	57%	$0 to $1.10
Southwest	2 430 500	57%	$0 to $.52
West Central	1 661 500	61%	$1.37 to $1.50
Southeast	1 644 600	65%	$.27 to $.50
Northeast	603 100	69%	$0 to $.10
Northwest	384 800	68%	$0 to $1.40
TOTAL	12 663 900	59%	$0 to $1.50

The Dynamics Of Tipping Fee Increases:

The dealers, wreckers or tire jockeys who deliver tires to landfills generally pay tipping fees at the gate. With the increase in tipping fee they will choose between:

- paying the higher tipping fee, or
- directing the tires to alternative destinations.

Even if productive use becomes a cheaper option after the tipping fee increase, that destination may not be selected by the generator. A range of other options exist:

Disposal by customer

Tire dealers can request purchasers of replacements to take the scrap tire home for discard in the regular MSW pickup, avoiding the tipping fee charge. Landfill operators have been noticing an increase in the tires showing up in the residential stream following the Hagersville tire fire.

Other Landfills

Landfills in other jurisdictions may be accessible at lower prices, within economic transportation distances. When Minnesota banned landfilling whole tires across the state Wisconsin experienced a significant increase in tire disposal at landfills.

Tire Piles

Tire piles will be the destination of choice if the cost of establishing and maintaining piles remains lower than the amount productive users are willing to pay. This was the reality of the pre-Hagersville period and may reappear unless closely monitored.

Illegal Activity

The higher the cost of alternatives, the more attractive are activities such as the accumulation of illegal piles, unauthorized dumping in rural areas and dumping at unattended landfill sites.

Thus higher tipping fees will result in the preferred productive uses only if the destinations listed are less attractive. Not unless they are perceived to be more costly (or less desirable for other reasons), will productive use be the destination of choice. Whether or not this occurs is largely a matter of government policy.

The Role of Tire Piles

Landfills are the legal destination of choice where they are the least cost alternative; the same is true for tire piles. Historically, tire piles have accumulated where cheap proximate landfill was not available. As the cost of landfill increased (or they were eliminated as a legal destination as in Waterloo) tire piles became more attractive.

In theory the piles were "incipient resource pools". In reality they have mostly been "above-ground landfills". The tires once in the piles, historically have found no other destination, without governmental initiatives and expense. The pile operator benefitted from the avoidance of the landfill cost -- by being able to charge a tipping fee (lower than the landfill) to the generator, or by avoiding the tipping fee if the pile operator is also the generator. The pile owner skimmed off the disposal cost incentive to productive use, while providing no final destination to the tire. The economic incentive to productive use was lost and had to be re-created, usually at public expense, if the pile was to be removed. Precisely the same dynamic will repeat itself if not checked.

Tire piles will build up as long as they are the least cost destination available to the generator. The OMOE has already expanded Regulation 309 authorization to include tire accumulations of more than 5,000, as sites requiring Certificates of Approval. Certificates will specify requirements for appropriate fire control and other measures necessary for proper pile management.

As noted in Chapter II this has already significantly discouraged further accumulation. However, this may be a short-term response to the uncertainty following the Hagersville fire. The extent to which this continues in the future depends upon the effective cost of these Ministry requirements.

Trends in Tire Manufacturing and Retreading

The major trend in passenger tire manufacturing and sales has been the move from bias ply tires to radials. This has had three important effects.

First, radials have extended the life of the tire by about three times that of bias ply tires. This has significantly reduced the quantity of scrap tires that would otherwise have been generated.

Secondly, the high performance standards established by these tires and the popularity of all-weather use, has accelerated the demise of the passenger tire retread market and restricted consumer acceptability of the lower performance standards that are associated with the use of chemically reclaimed rubber in passenger tire manufacture.

Thirdly, the modern radial with its blend of petrochemicals, fabric and wire has made chemical reclamation for tire manufacturing and tire recycling into other uses more complex and costly.

These constrain the extent to which policy and program instruments can be expected provide an effective stimulus.

The Market Dynamics of Scrap Tire Reuse and Recycling

As Chapter III has indicated, each of the options has a different potential for utilizing the more than 9 million scrap tire equivalents generated each year in Ontario. For example, retreading and crumb rubber recycling are not likely to be capable of handling the full quantity, at least in the short term, even if heavily stimulated by government incentives. Accordingly, options ranking lower on the environmental/materials priority scale, such as rubberized asphalt, will be necessary if larger quantities are to be put to productive use.

In the absence of specifically targeted incentives, underlying market forces will direct the tires to the lowest cost options. Chapter III demonstrates that the destination of choice for the largest quantity of tires is likely to be tire-derived fuel (TDF). Thus, experience in Europe and the U.S. with a relatively high proportion of TDF utilization may foreshadow Ontario's path.

Activities in Other Jurisdictions

Scrap tires are a problem across North America. Most major jurisdictions are currently considering a range of options to turn scrap tires to productive use.

This has two important consequences. First, strategies which predicate their expansion on establishing new markets elsewhere in North America are likely to encounter stiff competition from others seeking to do precisely the same thing. These strategies must be considered skeptically.

Secondly, other policy makers are funding R&D, demonstration programs and other activities which seek to establish technical and environmental performance requirements for the range of existing and proposed productive uses, such as rubberized asphalt. This provides the opportunity for sharing experience and saving resources through inter-jurisdictional communication and cooperation.

2. Criteria for Selecting Among the Market Development Measures

In order to make an appropriate selection concerning which mix of mechanisms to apply to which productive uses, it is useful to establish evaluation criteria to apply to the array of options. It is suggested that four criteria should guide consideration of the choice of policy measures.

These criteria may guide the OMOE in its selection amongst the range of policy options open to it. The elaboration of the criteria is meant to clarify the nature of some of the priorities and tradeoffs which OMOE faces. It is not meant to provide the basis for firm recommendations. It is not the role of this study to make recommendations concerning what the selection should be. OMOE will make the decisions, based upon these criteria and taking into account the factors described above plus other considerations.

Criterion A: Capability of Meeting Short-Term and/or Long-Term Objectives

In the short term the OMOE wishes to divert scrap tires from landfill and pile accumulation to productive use. The tire tax is available as a potential resource to undertake this.

In the short term the OMOE also wishes to establish the basis for a longer term sustainable diversion to productive use. In the longer term, sustainable diversion is likely to be that which can be supported by the then-prevailing market economics, including the disposal cost structure, perhaps in the absence of the tire tax.

Accordingly, it is important to consider a mix of measures and productive uses which supports both the short-term and the long-term objectives. Some uses, for example, may not be appropriate over the longer term (perhaps TDF, for example), but may serve an important bridging function, helping to establish the supply infrastructure and avoiding tire pile buildup.

Regardless of the productive re-uses selected, it is important that the measures have a good chance of actually diverting significant quantities of waste. Market potential is therefore an important criterion and, other things equal, high risk options should have a correspondingly higher payback.

Criterion B: Consistency with Environmental Objectives and Material Policy Priorities

Market pricing mechanisms guide materials to economically preferred end-uses. Environmental performance and longer term materials use sustainability do not figure prominently in this mechanism in the absence of government regulation and economic incentives.

Government funding priorities should reflect these values. The hierarchy of reduce, reuse, recycle, recover provides a rough guide to funding priorities. One approach to implementing this is through a weighting system which offers higher incentives to end uses performing better on this scale. This can be effected through differential criteria for capital cost funding, and by offering different operating cost incentives to different end uses depending upon their environmental and materials policy performance.

Existing Ontario government programs in other areas already reflect this approach. For example financial support for the Blue Box program gives priority to MSW recycling over disposal. Minnesota has demonstrated this latter approach in its pile remediation program, by accepting higher cost bids from higher priority performers.

Criterion C: Economic Cost

Other things equal, the OMOE should attempt to get the maximum "bang for the buck" from its initiatives. Of course, other things are never equal and it is necessary to make trade-offs between cost and the other criteria.

In making this trade-off it is important to note that cost may be a proxy for longer term market sustainability, and should be considered in this light, not just in terms of short term program funding maximization.

Criterion D: Equity

OMOE programs should reflect the importance of treating both consumers and producers fairly. Generally equity is taken to mean treat "like" groups and individuals "alike".

Since the OMOE will be engaged in making distinctions between producers on the basis of the criteria established under B, above (eg. between crumb rubber producers and TDF on the basis of environmental desirability) it is important that the choices made truly reflect the underlying environmental and material policy priorities and are perceived to do so.

As for the consumer, it may be useful to note that the current tire tax, because it is not currently applied to direct disposal costs, is perceived to be the source of double charging. The consumer pays the tire tax up front and then often pays a disposal fee to the tire dealer of one to two dollars per scrap tire.

The same is true for regional differences. While the tire tax is applied across the province, Ministry programs are likely to result in less diversion from landfill in the Northeast and Northwest. Some counterbalancing may be appropriate, for example, by encouraging applications with broad application across the province (eg. rubberized asphalt) or through transportation cost rebates.

The other dimension of equity which is of relevance, is that established by the Free Trade Agreement with the U.S. This provides a set of constraints against which all incentive policies must be considered.

C. Ontario Government Policy Initiatives to Date

This section explores OMOE's policy and program initiatives to date. These initiatives include programs dealing with municipal solid waste in general and activities which are targeted specifically at scrap tires.

1. Municipal Solid Waste

OMOE has promoted reduction reuse and recycling of MSW through a variety of programs and legislative initiatives. Currently providing the direction for this activity is OMOE's announced objective of diverting "to constructive uses 25% of Ontario's household and commercial-industrial waste by 1992 and 50% by the year 2000".[10] This goal is defined in terms of waste diversion from landfill and incineration.

Municipalities have been able to access funds to assist in 3Rs implementation through the Municipal Recovery Program. Funds have been available to finance programs which divert wastes from municipal landfill and incineration.

The Industrial Waste Diversion Program has existed since 1987, providing funding to industries which enhance recycling in their operations. This funding provided for research and development, capital costs and market development. A number of scrap tire recycling projects were funded under this program prior to the Hagersville fire and the announcement of the Scrap Tire Recycling Program (see below).

2. Scrap Tires

Since June 1, 1989 all new tires in Ontario have been taxed $5, plus sales tax, for a total of $5.40. While the tax has been levied on new tires, it was motivated by the problems created by the disposal accumulation of scrap tires.

In addition to the tire tax the Ontario government has directed two types of initiatives at scrap tires. The first concerns tire pile security and management following the Hagersville fire. The second deals with encouraging the productive use of scrap tires.

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[10] OMOE, News Release, March 10, 1989.

Tire Pile Security and Management

Following the Hagersville fire the Ontario government moved to ensure adequate security, fire regulations and pile management practices at Ontario's largest scrap tire sites.

Requirements included 24 hour security[11] and the enforcement of fire and related measures which specify separation into piles of 5,000 or less, lanes for vehicle access and water reservoirs.

To enhance its ability to enforce these and additional requirements, OMOE proposed modifications to the Environmental Protection Act and Regulation 309 under the Act.

Environmental Protection Act Changes:

Under OMOE initiated changes, stays of ministry orders are no longer automatic if the orders are appealed. In order to be granted a stay to suspend the requirements of the order the appellant must successfully apply to the Appeal Board or Court.

In addition, if the stay is granted, the OMOE may have work undertaken at public expense, with the power of entry onto private property to carry out the work.[12]

Changes to Fire Code and Fire Marshals Act:

Changes to the Fire Marshals Act empower the government to take immediate action in cases where there is a special risk to environment, not just risk to life or property. Fire Code changes create a special section to deal with tire storage depots specifically: strengthen fire prevention measures, improve site access requirements, enable improved on-site fire fighting measures and greater security for tire storage depots.

Changes to Regulation 309:

In April 1990, Regulation 309 was expanded to include scrap tires within its regulatory mandate. The key changes included the following:

- Used tires not refurbished for road use were added to the definition of designated waste. However, manifesting requirements that apply to transporters of liquid industrial and hazardous wastes were not applied to transporters of scrap tires;

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[11] The Ministry reported in its News Release, March 15, 1990 that 24 hour security guards were posted at 9 of the 11 largest sites, that "the 10th has a fence and guard dogs and the 11th is in a remote rural area and is virtually inaccessible"

[12] The OMOE can recover the expense by adding it to the municipal tax, thus becoming a preferred creditor.

- Used tire sites incinerating or burying tires, or containing more than 5,000 tires, were designated as "waste disposal sites".

Accordingly, OMOE now requires Certificates of Approval for storage piles of more than 5,000 tires.[13] These Certificates specify the terms and conditions under which the piles may operate, including security, fire and other provisions deemed appropriate by the Ministry.

Scrap Tire Recycling

Ontario Tire Recycling Program:

In March of 1990, OMOE announced the Ontario Tire Recycling Program[14], a five part initiative, initially funded at $16 million, to provide:

1. Support for collection, handling and sorting of scrap tires.
2. Funds for developing and implementing used tire processing and recycling technologies.
3. Funds for research into tire-derived products and market development.
4. A program to secure, clean up and eliminate large tire stockpiles in Ontario.
5. Funds to "underwrite the use of recycled tire rubber in rubberized asphalt paving for roads, walks and parking lots"

In announcing the program, the Minister stated: "The tire recycling program is part of the government's policy of diverting from landfill and incineration 25 percent of municipal solid waste by 1992, and at least 50 percent by the year 2000."

This program significantly extends and enhances the scrap tire recycling support that was already taking place under the Industrial Waste Diversion Program. Currently over 30 applications have been received, and funding is expected to be announced for some of these shortly.

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[13] The amendments provide for a grace period giving existing sites a time limit for acquiring the Certificate. In the meantime, the security and fire regulations described above, will apply independently of the Certificate.

[14] OMOE News Release, March 15, 1990.

3. OMOE's Current Policy in Context

The Ontario government currently has the highest tire tax of any jurisdiction, generating an estimated $40 million of revenue annually. OMOE has increased its control over scrap tire management, significantly tightening the regulation of tire piles. OMOE has also increased its funding allocation to scrap tire recycling programs, providing monetary incentive for research and development, and capital costs for all activities related to tire recycling. While these initiatives are substantial and important the following should be noted.

First, the post Hagersville period has witnessed a significant decrease in collection network activity. The new requirement for Certificates of Approval for tire piles has increased dealer and collector uncertainty. Tightened regulations have constrained activity without there being, as yet, any defined incentive for prospective operators to seek and obtain Certificates of Approval under the new regime. Without clear incentives and/or enhanced monitoring and enforcement of tire disposal, small piles and illegal activity are likely to proliferate. OMOE can wait for the network to redevelop, enhance enforcement to prevent illegal activity and/or provide incentives to accelerate network development.

One form the incentives can take is funding out of the tire tax to compensate for disposal costs. While the rationale for the tax is scrap tire disposal difficulties, none of the tax as yet goes to compensating for the costs of actual disposal. If a portion of the tax were provided to dealers (or others) for the expressed purpose of financing legitimate disposal, reluctance to pay pile operators (and others) what they need to meet the new regulations might dissipate, prospective pile managers and others (eg. landfill operators not currently accepting scrap tires) may emerge. Options for dealing with this are discussed in more detail under pile management.

Secondly, as discussed in Chapter III, a significant short, or even medium term increase in recycling activities is speculative, even with significant financial support. Recycling will benefit from economic backing, but is unlikely to solve the problem. Accordingly a balance of short, medium and longer term program activities are required, to ensure that OMOE's objectives are met.

D. Encouragement of Productive Use

The two levers for promoting productive use are providing a disincentive for disposal related options and discouraging disposal options and encouraging options for reuse.

1. Options for Discouraging Disposal

An adequate supply of tires at a suitable price is essential for their productive use. As Chapter III indicated, recycling and energy recovery may require $.50 to $3.00 or more per tire to be economically feasible. Cheap disposal in landfills has played a major role in preventing this in the past. The current trend to increasing disposal costs provides the clearest and most powerful incentive to a reversal of the current pattern of scrap tire disposal. OMOE has already indicated its general support for the current trend to increased MSW disposal charges.[15] However, without ancillary support the tires may end up whole in landfills (disposal by customer, or diverted to a landfill in other jurisdictions, within or outside Ontario), tire piles, or in illegal disposal.

OMOE has two broad alternatives. The first is to play no active role in ensuring that the municipally imposed waste management increases are translated into a direct incentive for productive use. The second alternative is to take advantage of the unique provincial authority of OMOE and provide needed supplementary support. A number of actions which OMOE could take are described below. It should be noted that unless an appropriate pile management policy is adopted by OMOE, none of the following will be effective, because tires will eventually accumulate in piles. Pile management options are described in section E, below.

Require Mandatory Shredding Prior to Landfill

OMOE could impose a cross-province requirement for shredding prior to landfill. As Table 29 shows, Florida and Washington among others have instituted state-wide bans on whole tire landfilling. Several landfills in southern Ontario no longer accept whole tires and the number is increasing.

Advantages

- The cost of shredding ($0.50 and higher, depending on quantities, location, etc.) coupled with landfill tipping fees would hasten the disappearance of cheap, legal landfill disposal in Ontario, increasing the competitiveness of productive use destinations, and decreasing the flow to landfill.
- Landfill space would be conserved, even if no tires were diverted to productive use, because significant volume savings result from shredding.
- Scrap tires confronting high tipping fees in one jurisdiction would not find a cheap haven in another Ontario municipality.

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[15] For example, see OMOE, *Towards a Sustainable Waste Management System: Discussion Paper*, Queens Printer, 1990.

Disadvantages

- High cost disposal for scrap tires in areas where landfill is plentiful, the cost of shredding is relatively high and alternative productive use destinations are not economic (eg. some northern areas).
- Encourages flows of scrap tires out of the province, where shredding is not mandatory eg., Quebec, Manitoba, New York State.
- Encourages flows to illegal destination, especially in the absence of adequate monitoring and enforcement.

Increase Monitoring and Enforcement

OMOE could increase its monitoring and enforcement activities, either on its own, or in conjunction with municipal authorities. This could include increased penalties for illegal disposal, as well as intensified enforcement activity.

Advantages

- Helps to cut down on illegal disposal and shipments to landfills in other jurisdictions.
- Encourages flows to productive use.

Disadvantages

- Increases administrative costs.
- May be relatively ineffective in encouraging productive use unless combined with other measures, such as economic incentives.

Require Manifesting of All Scrap Tire Flows

OMOE could require records to be kept for all scrap tire flows. Table 29 gives examples of states which have implemented documentation requirements for tire generators and processors. Currently scrap tires are exempted from the Regulation 309 manifesting requirement. This exemption could be removed. In the alternative, a less onerous system could be implemented, requiring key actors (eg. dealers, disposal site operators) to maintain records but not demanding that forms be submitted with each shipment as in the manifest system. Dealers and others required to keep records could be paid a sum to cover administrative costs.

Advantages

- Provides basis for audit to support economic incentives and increased monitoring and enforcement, thereby decreasing illegal flows and encouraging productive use.

Disadvantages

- Increases administrative burden and thus cost of handling scrap tires.
- May be ineffective in the absence of ancillary measures such as economic incentives.

Provide Economic Incentives to Proper Disposal

OMOE could offer payment for proper disposal of each tire, funded from the tire tax. The payment could be tiered, giving more for shredded than for whole tires, thus encouraging measures reflecting the hierarchy in keeping with criterion B. It could also be structured to reflect differences in regional opportunities, addressing criterion D equity concerns.

In order to stimulate non disposal destinations, the subsidy payment system would have to be extended to recycling options and could be tiered according to environmental priorities (criterion B considerations).

To maximize the impact of the measures, the payment should be made to the disposer/processor. Thus the payment to the disposer/processor should be reflected in a lower charge to scrap tire generators (progressively lower for more environmentally appropriate destinations) than in the absence of the subsidy.

Alternatively, a deposit system might be used, providing the generator/disposer with a refund at approved disposal locations.[16]

Advantages

- Provides the incentive to engage in proper disposal activities, and can reflect criterion B environmental and materials policy concerns. Can thereby encourage productive use.
- Directs a portion of the tire tax revenue directly to dealing with the scrap tire, thus addressing the criterion D equity issues of double payment by the consumer.

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[16] Quebec is currently considering a deposit system.

- Where landfills currently ban whole tires, the subsidy offers the potential for operators to provide a disposal destination in those jurisdictions by giving the economic basis for landfills to finance shredding of tires.

Disadvantages

- May provide an incentive to disposal, if not structured properly.

- May create dependency on ongoing subsidy, especially by productive uses, thereby not satisfying long run viability concerns of criterion A.

- Subsidy may not be passed on to dealer or consumer; tipping fees may remain the same as they would in the absence of the subsidy: criterion D equity concerns.

The next section considers the options for encouraging productive use.

E. Options for Directly Encouraging Reduction and Productive use

Chapter III has described the existing and potential markets for productive use in detail. This section discusses the policy options for encouraging reduction and productive use of scrap tires.

1. Reduction

Decreasing the amount of scrap tires going to disposal and storage begins with reducing the scrap tire generation rate. Scrap tire generation can be reduced by:

- decreasing the number of tires in use, and
- by extending the lifetime of the tires which are in use.

The number of tires in use depends upon transportation technology, economics and lifestyle variables. Governmental initiatives to encourage decreased tire use fall into transportation and energy policy and are related to broader and longer term issues pertaining to energy consumption and related emissions, such as CO_2, NO_x and VOCs. While clearly important, these issues are not within this study's frame of reference, but merit consideration as part of the evaluation of Ontario's commitment to an environmentally sustainable economy and the policy measures necessary to support it. Nonetheless, reducing total quantities in use will not play a significant role in solving tire disposal problems over the time horizon of this study.

Tire lifetime has been significantly extended via the introduction of radials. This demonstrates that powerful incentives encouraging this trend already exist, and suggests that in the short term at least government policy initiatives in this area are likely to be relatively weak and superfluous.

2. General Policy Initiatives for Encouraging Productive use

Increasing the disposal cost will help to provide a supply of scrap tires for productive use. However, unless the provincial government establishes pan-provincial requirements, such as a mandatory shredding, the cost of disposal will remain tied to the policies of the individual disposal site operators and will probably not provide sufficient stimulation to meet the province's diversion objectives within the specified time frames. Encouraging productive use directly through subsidy or other measures can provide an essential inducement, reinforcing the pressure exerted by disposal costs and accelerating the development of non-disposal alternatives (meeting Criterion B's environmental and materials concerns). At the same time such backing carries with it the risk of economic waste and of encouraging reuses which will be unsustainable over the long run without ongoing government support (Criteria A and C).

OMOE's present policy clearly demonstrates its decision to promote accelerated reuse or recycling. This section examines options for delivering this support. The section first lists and briefly describes measures available to encourage reuse or recycling, many of which are already offered by OMOE. Next the advantages and disadvantages of four different measure categories are listed (up-front incentives, performance incentives, government procurement and research and development). Finally application to specific uses is discussed.

The policy measures available for increasing the market for productive use are:

- expanding the quantities demanded for products using tire-derived materials which are economically competitive under the prices which productive users are currently willing to pay for the scrap tires, and

- increasing the price which productive users are willing to pay for scrap tires.[17]

Policy Measures to Encourage Expanding Markets

Expanding markets for products can be encouraged by funding market development initiatives by existing and prospective producers, and by providing a ready-made government market through government procurement commitment.

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[17] As indicated in Chapters II and III, the "price" is often negative -- recyclers and others often require a fee to take the tire, given current technology and economics. "Increasing the price", then, means decreasing the fee which they require.

Funding Market Development Initiatives:

- Market Research and Development Studies (eg. new crumb rubber applications).
- Demonstrations Of New Product Applications.
- Evaluation of the Environmental Performance of Technologies or Products (eg. rubberized asphalt, TDF).
- Export Development (eg. promotion of market for Ontario scrap tire casings in other countries).

Advantages

- Can provide effective assistance for applications where cash for market development is in short supply, where development of information has beneficial effects beyond specific producer (eg. environmental performance data can clarify potential for a number of additional producers) and where marginal effort by government may have significant effects (eg. export promotion by existing Ontario government trade offices).
- Can be targeted to environmentally preferred uses.

Disadvantages

- Often high risk of no impact; may result in no more tires being reused or recycled. May not really require government funds.

Implementing Government Procurement Commitments:

- Providing preference in government purchasing to products with recycled rubber (eg. retreaded tires, rubberized asphalt in highway applications)
- Mandating minimum recycled rubber requirements for specified products (eg. specifying a regulatory requirement for recycled rubber requirement in automobile production)

Advantages

- Can provide an important first (or additional) market for demonstrating products without adequate current outlets.
- Can be targeted to environmentally preferred uses

Disadvantages

- May not result in activity by any producer and thus in no additional tires being reused or recycled. Requires careful scrutiny of technical performance and related requirements before implemented.

Policy Measures to Increase Willingness to Pay

The willingness to pay for scrap tires can be increased through up-front funding incentives and by providing performance based subsidies. The former is currently offered by OMOE; the latter is not.

Up-Front Funding:

- Research and Development Grants
- Grants for Plant Expenditures
- Funding of Start-up Environmental Monitoring
- Low Cost Loans for Capital Expenditures

Advantages

- Can provide effective assistance for applications where capital funding is a barrier to entry and where R & D may bear fruit but infrastructure is lacking (criterion A).

- Can be targeted to environmentally preferred uses (criterion B) .

Disadvantages

- Because it is not tied to performance, may not result in scrap tires being reused or recycled and therefore waste of government funds (criterion C concerns).

- May foster ongoing dependence upon government funding because it does not necessarily require medium to long term sustainability (long term sustainability concerns, criterion A).

- A large degree of discretion may be required by government decision makers because of competing proposals for funds; predicting market performance is difficult (effectiveness and equity: criterion D).

Performance Funding:

- Payments Per Kilogram Of Ontario-generated Scrap Tires Used

Advantages

- Directly based upon tires used, so funding not wasted for projects which do not materialize.
- Can be combined with payments for disposal (see "Provide Economic Incentives to Proper Disposal", Section D above) in an integrated system of rebates for all scrap tires handled in an acceptable manner.
- Can be targeted to environmentally preferred uses (tiered payments for uses higher on the hierarchy).

Disadvantages

- May foster ongoing dependence upon government funding because it does not necessarily require medium to long term sustainability (long term sustainability concerns, criterion A).
- Without manifest (or other tracking system) may have problems verifying that tires used are from Ontario.
- Requires payment for scrap tires already being put to productive reuse (eg., Ontario scrap tires currently utilized by manufacturers of crumb rubber).
- May not result in scrap tires being used if funding level not high enough or commitment not sufficiently long term to induce investment.

Table 29 summarizes program commitments in selected U.S. states and those elements of the Ontario program already in place.

It is clear from the foregoing that the measures each have different strengths and weaknesses, which may be more applicable to some end uses than to others. It is also evident that more than one may be adopted for any specific end use. Finally, the selection of measures will be conditioned by the initiatives that have been selected for supporting disposal cost increases

Table 29
Sample Policy Initiatives in Selected U.S. States and Ontario

INITIATIVE	U.S. State	Ontario
Ban on landfilling of whole tires	Oregon Minnesota Washington	Yes
Pile remediation program	Minnesota Oregon Washington Florida Wisconsin	Yes
Tire tax	British Columbia: $3 per tire Oregon: $1 per new replacement tire Minnesota: $4 vehicle transfer fee Washington: $1 per new tire Florida: $1 per new tire Wisconsin: $2 annual vehicle registration fee	Yes: $5 per tire plus tax
Licensing of scrap tire storage facilities	Minnesota Washington Florida	Yes
Licensing of scrap tire processing facilities	Minnesota Florida	Yes
Requirements to use licensed haulers	Oregon Washington Florida	No
Reporting requirements for haulers	Washington Florida	No
Financial requirements for storage and processing facilities	Oregon: post bond equivalent to $1 per tire Washington	Yes
Research grants	Florida	Yes
Performance subsidy for productive use	Oregon: $20/ton for use of in-state generated tires Wisconsin: same as Oregon	No
Grants for establishing transfer facilities	Minnesota	Yes
Grants for developing processing facilities	Minnesota (crumb rubber)	Yes
Grants to demonstration projects		Yes
i) Rubberized asphalt trials	Minnesota Oregon Florida	
ii) Roadbed trials	Oregon	No
iii) TDF trial burns	Minnesota	No
Public education	Minnesota	
Penalties for non compliance	various states: eg. Florida $10,000 per day for any non-compliance tire-related regulations	Yes

(Section D above) and for pile management (section E, below).

Thus the range of options is very wide. Rather than make an exhaustive list, the following section discusses some of the overall factors which are pertinent to measure selection and then examines issues for application to specific end uses.

3. Market Incentives and Specific Productive End Uses

Table 30 presents the estimated tipping fee required to ensure economic feasibility for each of the major productive destinations. The table shows that the three most competitive of the productive uses are the highest on the criterion B performance list: resale, reuse and crumb rubber recycle. Thus, if these end uses were capable of taking all of the scrap tires generated a disposal cost well within the range of that currently being charged at many of the province's landfill ($.60) would drive a large portion of Ontario's scrap tires to these environmentally preferable end uses.

Table 30

Landfill Costs and Tipping Fee Requirements

Current Tipping Fees:$0 to $1.30/tire

PRODUCTIVE USE	ECONOMICALLY FEASIBLE TIPPING FEE ($/TIRE)
Resale	-$27.50 to -$12.50
Retread	-$ 2.25 to -$ 1.30
Recycle	
Crumb rubber	$ 0.60 to $ 0.75
Whole tire	$ 2.00 to $ 3.00
Highway asphalt	$ 2.00
TDF	$ 0.50 to $ 1.30

However, Chapter III established that this is not the case. Resale and retreading, while capable of some expansion, are not likely to provide a significantly increased market for scrap tires for the foreseeable future. As for crumb rubber, expansion opportunities are speculative and even at best, in the short term, will not able to take close to the balance of Ontario's scrap tire quantities. It is possible, though still speculative, that the longer term role of crumb rubber could increase significantly. Thus uses lower on the environmental scale appear necessary, at least in the short to medium term.

Highway asphalt applications, hold out the prospect for a very large volume use, but require further testing in Ontario conditions. Tire derived fuel also has a large potential market in Ontario, but must satisfy environmental concerns. These issues are taken up in more detail below.

Reuse

Reuse includes resale of used tires and tire retreading. In theory these can be encouraged by:

A. *Increasing The Price Differential Between New And Reused Tires*

The disappearance of the retreaded passenger tire appears to be an almost universal trend in industrialized countries. Resale and retreaded tires have a natural price advantage. The tire tax, which applies only to new tires, has increased this advantage since 1989. However, there is no evidence that this will provide an adequate incentive to stimulate the moribund passenger tire retreading industry and counter the trend.

B. *Expanding The Market At the Existing Price Differential*

Chapter II has described the factors which have limited retreading activity. Government initiatives to encourage the expansion of the market at the existing price differential include:

Purchasing Policies

Government could give preference to retreaded tires in government fleet purchases. This could serve the dual function of providing a ready market for retreaded tires and help counter the public's negative perception of the product.

However, before such an initiative is taken, the technical and economic feasibility of this option should be pursued in depth, by examining the government fleet requirements, safety implications, and the quantity/price inducement that could thereby be provided to Ontario retreaders.

Export Support

Existing Ontario government export development initiatives (eg. trade offices) could help the existing industry identify opportunities in countries where reuse and retread still form an important component of the passenger tire market.

Recycle

A. Crumb Rubber

Crumb rubber use has the advantage of being economically competitive at tipping fees currently charged by many Ontario landfills and rating highly on the environmental/materials use scale.

Crumb rubber provides two different opportunities. The first is import substitution. The major Ontario user of crumb rubber currently imports from the U.S. A shift to an Ontario-based network could relatively quickly and significantly increase tire recycling. Concerns relate to the importance of establishing a shift which is sustainable over the longer term (criterion A) and possible free trade issues (criterion D). On the latter point it is useful to note that U.S. states are currently providing incentive programs for domestically recycled rubber. Nonetheless the free trade issue should be investigated more closely to ensure that any financial incentives to Ontario producers that result in the loss of Canadian markets currently served by U.S. producers are not considered "unfair" subsidies.

In theory capital grants or operating subsidies funded by the tire tax can provide incentives to accelerate this development. Up-front grants have the advantage of having more of a "one off" character, but may result in little or no domestic diversion, as Minnesota's experience has demonstrated. Performance based incentives relate directly to quantity diverted but are difficult to verify in the absence of a manifesting system, and equity considerations may demand that recycling already taking place in the absence of government incentives receive funds as well. This runs counter to cost-effectiveness concerns (Criterion C).

The second opportunity is via the development of new markets, in Ontario and elsewhere. By nature, market development is speculative. The short run payoff may be small, but crumb rubber may offer one of the most promising long run solutions for environmentally appropriate tire recycling. The market development incentives mentioned above could help to accelerate this, but must be referenced to effectiveness concerns and an appropriate risk/return balance.

Over the longer term government procurement policies could also play an important consciousness-raising role as well as a potentially important market (eg. sports and recreation capital expenditures).

B. Rubberized Asphalt

Rubberized asphalt's major potential advantages are its large diversion potential and its environmental/materials performance rating, its large established government-based market and its potential for providing a feasible outlet in parts of the province remote from the major population centres.

Major concerns are technical performance (including subsequent recyclability of the asphalt and air emissions from asphalt plants which are important elements of its environmental rating). An average subsidy of $2 per tire or more will be required, at least in the early stages of widespread use of rubberized asphalt.

Even if the cost structure of asphalt does not prove competitive over the long term, the resolution of technical concerns could allow the material to play a significant role in scrap tire recycling. It also could provide a medium term market for crumb rubber manufacturers who might be able to use it as base from which to expand markets for other crumb-based products.

C. *Whole Tire Uses*

Some of the proposed whole tire applications have the capability of utilizing large quantities of scrap tires and offer the additional advantage of a regional balance of opportunities.

Some of the schemes are very speculative and many have relatively high costs, partly because of long transportation distances. For most of the applications the key issues will be cost and their real performance under Criterion B (Environmental Objectives and Material Policy Priorities).

The most important function for many of these schemes may be their short-term pile remediation and bridging capability, rather than their capability of providing a sustained longer term solution.

Energy and Materials Recovery

A. *Tire Derived Fuel*

TDF's positive characteristics include proven technology, relatively attractive economics and the capability of handling large quantities of scrap tires over the short and longer term. The pulp and paper industry provides a potential outlet for scrap tires in Northern Ontario.

Concerns about TDF include environmental performance and relative materials policy desirability.

OMOE could address public concerns about environmental performance by ensuring that the testing protocol for currently planned and future trial burns will enable it to draw conclusions about the conditions under which the technology will be environmental acceptable for Ontario. This issue is currently being examined by a number of jurisdictions across the continent and provides the opportunity for fruitful communication and perhaps collaboration.

TDF is currently eligible for capital funding support under the Ministry of Energy's Energy From Waste Program and appears relatively economically attractive without ongoing subsidization. This suggests that additional funding may be redundant (cost effectiveness, Criterion C), though equity concerns (Criterion D) may argue for making any operating cost subsidies offered to other options also available to TDF, albeit it at a level consistent with environmental and materials policy priorities (Criterion B).

B. Materials Recovery

Chapter 3 has shown that pyrolysis and related technologies have yet to demonstrate technical and economic feasibility. The major issues continue to be technology related and the low value of the char that is produced.

Technology development has already received significant corporate attention, including major initiatives during the period of high energy prices. Accordingly further funding requests for technological development should be approached with caution and concern for an appropriate risk/return payoff.

If technological issues could be resolved in a manner which offers attractive economic performance, pyrolysis offers the enticing prospect of providing an important element of a long term recycling strategy. The technology offers the potential to recover virtually all of the tire's material components and is thereby a relatively high performer with respect to Criterion B (environmental and materials policy priorities).

A number of these themes is taken up in the section on pile management, below.

F. Tire Pile Management

There are three sets of issues which pertain to tire pile management: remediation of existing piles, the role of tire piles as acceptable destinations in the short term as a way of dealing with the lack of recycling destinations and the longer term issues of piles and their role in the scheme of scrap tire management in Ontario.

This section deals with the issues in reverse order, since the shorter term issues must be considered in light of the decisions which are made concerning the longer term role of piles

Following Hagersville, the Ontario government made changes to Regulation 309 of the EPA which require tire piles over 5,000 to have a Certificate of Approval. The conditions attached to these certificates will determine the nature and role of tire piles in the management of Ontario's scrap tires.

All piles will have appropriate security, fire and related management conditions attached to them. The key issues relating to these conditions and to the tire piles are:

- What are the appropriate security, fire and related conditions for any tire pile?
- Should additional conditions be attached which will regulate the longer term role of the pile? In particular, should piles be permitted as a final destination; if so under what conditions?

1. Options for Security, Fire and Related Conditions

In Florida, piles are restricted to areas 200 ft. x 50 ft. x 15 ft. (height) with a minimum of 50 feet perimeter between piles (measured at pile base). California also restricts tire pile dimensions. It is beyond the scope of this study to make recommendations concerning specific pile management details.

It should be recognized that the more stringent the regulations, the less likely will there be a repetition of incidents like Hagersville. At the same time it should be noted that the cost of very tight security and fire regulations will discourage the accumulation of piles over both the short and long term. OMOE may decide that this is the preferred option. However, it will be understood that, in the absence of other alternatives including monitoring and enforcement of tire flows, the impact of very restrictive requirements may counter the desired outcome. The number of piles under the 5,000 minimum regulatory requirement is likely to increase and so might illegal pile accumulation and illegal disposal activities.

Additional conditions attached to these certificates will govern the piles' long term role. The options for these conditions include:

Option 1: Attach no additional conditions; permit piles as final destination without additional provisions.

The advantage of this option is that it will provide a legitimate, (relatively) cheap destination for scrap tires under monitored conditions, saving landfill space. This is an especially important option in jurisdictions where there is no landfill currently accepting whole tires.

The disadvantage is that the piles will continue to accumulate and that there is no guarantee that the pile be removed if the owner violates the conditions of the certificate. In Florida additional handling costs of $0.30 per tire have been experienced in removing scrap tires from piles. This is a pure handling costs which excludes costs of shredding (which will also increase with dirt contamination) and transportation which will vary from site to site.

Option 2: Attach additional conditions requiring provision of perpetual care.

Under this option, the additional conditions would demand funding of security, fire prevention and related services in perpetuity.

Advantages

- Piles continue to exist as final destination, providing legal alternative and saving landfill space.
- Ensures that funds are available to permit continuing care for the site, even in the event of its abandonment or certificate violation by the site operator.
- Higher cost provides additional incentive to alternatives

Disadvantages

- Piles continue to accumulate, with attendant risks and discouragement of alternative uses.
- Higher costs encourage small pile accumulation and illegal disposal.

Option 3: Attach additional conditions ensuring that the pile is a temporary destination.

The conditions would require up-front financing adequate for the movement of the scrap tires from the site to an alternative destination (eg. used in asphalt applications or shredded and landfilled) and could require such movement within a specified time frame.

Advantages

- Piles do not accumulate indefinitely, thus reducing pile-related risks.
- Alternative uses are encouraged.
- Public liability minimized.

Disadvantages

- Lack of long term destination encourages small pile accumulation and illegal disposal.
- Increased cost of tire disposal.

Some combination of Options 2 and 3 is possible. For example, the perpetual care requirement under Option 2 would be waived if the pile operator made a financial commitment commensurate with moving the scrap tires to an alternative use.[18]

The next section discusses the problem of remediating existing piles not currently acceptable to OMOE.

2. Tire Pile Management: Remediation

There are few options for the remediation of tire piles not in compliance with Ministry requirements. The piles must be brought up to an acceptable standard or they must be removed. If the existing piles do not meet the OMOE Certificate of Approval requirements within the specified period, then the Ministry has two main options.[19]

Option 1: Contract out pile removal

The OMOE can entertain bids for a contractor to remove the tires. The criteria used in selecting the successful bidder may include the proposed destination of the tires, placing a premium on proposals which avoid landfill, incineration or other tire piles. This has been the approach used in Minnesota, where the successful tender need not be the lowest, if a higher priority destination such as reuse or recycling is proposed.

The public purse has generally funded pile removal in other jurisdictions. One option, which appears to be both anticipated by and consistent with the recent changes to the Environmental Protection Act, is for OMOE to proceed with pile removal at public expense and subsequently pursue the owner for costs.

The cost of remediation will depend upon the location and condition of the pile and the remediation destination for the tires (export, Ontario crumb rubber, shred and landfill, TDF, etc.). Quebec contracted out removal of the St. Amable pile (prior to the May 1990 fire) at about $0.70 per tire, a price which officials there currently consider unrealistically low under current conditions.

Advantages

- Eliminates risk posed by pile.
- Offers the lowest cost option under current conditions.

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[18] This is relevant, of course, only if the cost of perpetual care exceeds the cost of alternative use.

[19] Legal aspects have not been considered in the options discussion.

- Provides possibility of directing to environmentally desirable uses through preferential contract selection process.

Disadvantages

- May eliminate preferable use, if better destination emerges subsequently (eg. it may be necessary to shred and landfill now, but asphalt applications could emerge shortly).

- May shut down a destination which could provide an important short term stopgap or legitimate long term destination under proper management.

Option 2: Continue operation under different management.

The Ministry could seek to change the management and have it operated under a new Certificate of Approval. Existing sites may be able to play an important interim role as a destination for tires generated locally or from other municipalities.

The municipality may be a good candidate to take this on, especially if the local landfill is reluctant to accept tires or regional solutions are required.

This option is only relevant if the Ministry decides that well managed tire piles have a legitimate short and/or longer term role to play in the province's scrap tire management strategy.

Advantages

- Provides an already established site for local or regional scrap tires under good management; particularly important in the short term.

Disadvantages

- Can discourage other alternatives emerging, especially if pile continues indefinitely.

- May merely delay and thus increase the cost of the inevitable pile removal operation.

3. Tire Pile Management -- Role in Providing a Short Term Destination

The immediate concern of the government following the Hagersville fire was to ensure that the fire itself was handled appropriately and to avoid a repetition elsewhere. As described above, the government responded with action at Hagersville, and other initiatives aimed at guaranteeing appropriate security and pile management.

In the aftermath of the fire and the governmental response to it, there has been a sharp decrease in the flow of scrap tires to piles. The collection network has ceased to function in a number of areas, leaving generators to find legitimate outlets on their own. This is a particular problem for those jurisdictions in which the landfill has refused to take tires, since the generator is without a legal local alternative.[20] It also creates difficulties for those municipalities who have been segregating tires to conserve space and are now without an identifiable legitimate destination for their tires.

While OMOE has not shut the door to tire pile approvals, private sector operators have not stepped forward, in part because of uncertainty about the OMOE position on the desirability of piles, and partly because of the lack of clear financial incentives.

The options which the Ministry has in the present time are:

Option 1: Encourage the development of piles to take tires from jurisdictions where no legitimate destinations currently exist.

OMOE will approve sites which meet the required criteria for tire pile operation. OMOE could actively encourage operators to come forward for approval by:

- Publicizing the necessity for the piles in localities of particular need.
- Ensuring that the approvals process acts expeditiously on applications that are brought forward.
- Ensuring appropriate monitoring and enforcement of illegal tire flows.
- Ensuring that appropriate financial incentives are available for tire operators, through generator payments or other mechanisms (see below).

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[20] Chapter II has shown that about one-quarter of the municipalities surveyed no longer accepted whole tires at the local landfill.

In the short term at least, municipalities may be the best candidates[21] for pile operation, at existing landfill sites, other suitable municipal property or even at the site of current piles whose owners are unable or unwilling to comply with OMOE requirements.

OMOE could actively solicit municipal cooperation in this regard to ensure, over the short term, a legitimate destination for tires generated in each Ontario jurisdiction. In some cases it may be appropriate to encourage the development of a pile operation to take tires from several jurisdictions.

Clearly the pile will be the final destination for the tires only if the pile is so considered by the operator and permitted to exist as such by the OMOE (see the long term options above). Otherwise the pile is a storage site and there must be adequate incentives/resources to ensure that the tires reach an acceptable final destination. In this latter case, as discussed above, the Certificate of Approval will contain suitable conditions to guarantee that this takes place.

Financial Incentives:

While it is straightforward to specify these conditions in the C of A, the financial implications for the operator may rule out a profitable operation in the absence of guaranteed funding or stringent enforcement. For example, a pile operator whose only assured alternative destination is landfilling following shredding, may be forced to charge the generator $3 (or more) plus transportation, per tire. This would cover the cost of pick-up and unloading at the pile, plus subsequent shredding, transport and tipping fee charge at the landfill (if a more attractive alternative does not emerge in the meantime). It is understandable that dealers and other generators will be reluctant to use this route, charging the customer another $3, when the $5.40 tire tax has already been levied on the replacement.

The OMOE could provide financial incentives, using revenue generated by the tire tax. The options, some of which were already discussed in Section D, above, include:

- Rebate to the dealer of a portion of the tire tax to cover disposal charges. To ensure that this amount actually finds its way to the pile operator or other final disposer, this should be accompanied by the requirement that the dealer matches each replacement tire with a scrap, and that the dealers are prohibited from charging customers extra for scrap tire disposal.
- Direct payment to the pile operator for each tire sent to a final destination. This payment could differentiate on the basis of desirability of final destination, paying more for recycling.

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[21] Municipalities often have existing sites with the necessary approvals, waste management expertise, and the responsibility for waste management. They also bear the brunt of illegal disposal activity and the "customer take home" tire disposal "solution".

- Payment for periodic pile removal. OMOE could administer and fund the contracting out of pile removal, once the pile had reached a specified size. The amount of the payment could also be based on the desirability of the final destination.

Payment to dealers and payment for pile removal could be combined. For example, the dealer payment could reflect an average cost of transport and disposal and the payment to the pile manager or remediator would be based directly on the cost/value of subsequent destinations.

Advantages

- OMOE encouragement of interim pile development provides a legal destination in each jurisdiction, discouraging illegal destinations.
- Can encourage municipal involvement in pile development, decreasing total cost to public purse.
- Encourages development of collection infrastructure which can be used subsequently for more desirable destinations (eg. recycling).

Disadvantages

- Can provide false stimulation to pile development, discouraging other alternatives emerging, especially if pile continues indefinitely; unlikely that future markets will be able to handle quantities and tire is likely to end up as TDF or shredded and landfilled.
- Can increase cost of disposal, through double handling, especially if final destination is local landfill (eg. post shredding).

Option 2: Do Nothing Additional to Encourage Development of Interim Piles

OMOE can allow pile development to take its own course, taking no special initiatives to encourage prospective pile operators.

Advantages

- Piles do not accumulate indefinitely, thus reducing pile-related risks.
- Alternative uses will be encouraged.
- Public liability for subsequent pile removal is minimized.

Disadvantages

- Lack of long term destination encourages small pile accumulation and illegal disposal.
- Increased cost of tire disposal.

G. Summary and Conclusions

The OMOE faces three major policy challenges. The first is to decrease scrap tire generation and promote the diversion of scrap tires from disposal to productive use.

The second policy challenge is to determine under what conditions scrap tire piles should be permitted to accumulate. In the short term recycling can absorb only a fraction of the scrap tires that are generated in Ontario. The remainder must either be disposed of or stored in anticipation of new markets being developed for products containing recycled tire materials.

The third policy challenge is to create environmentally-acceptable destinations for scrap tires. In the aftermath of the Hagersville tire fire and the Ontario Government's response to it, the scrap tire collection network has ceased to function in a number of areas of the province due to the closure of many of the sites that previously accepted scrap tires.

An adequate supply of scrap tires at a suitable price is essential for their productive use. Recycling and energy recovery requires a payment to the processor of $0.50 to $3.00 per scrap tire for these management options to be economically feasible. Cheap disposal in landfills in the past has played a major role in diverting scrap tires from productive use to disposal. The current trend to rapidly increasing landfill disposal costs provides the clearest and most powerful incentive to find other management options for scrap tires.

Policies that would discourage scrap tire disposal and encourage productive use are: require shredding prior to landfilling, which will raise the cost of disposal by about $0.50 per tire; increase monitoring and enforcement to cut down on illegal disposal and prevent shipment to jurisdictions with low landfill tipping fees; require manifesting of all scrap tire flows which would provide a basis for monitoring and enforcement; provide economic incentives for recycling scrap tires through direct payments to processors; funding of product and market development; and government procurement policies that favour goods containing recycled materials.

Although the OMOE has implemented a scrap tire management program that contains elements of most of the policy options outlined in the previous paragraph, some fundamental problems remain. Tire dealers and other scrap tire generators are finding it increasingly difficult to find legal destinations, at a reasonable price, for their scrap tires. In many areas of Ontario, consumers are being charged a scrap tire disposal fee, typically of $1.00 to $2.00 per tire, in addition to the tire tax, by tire dealers, when they buy new tires. This would indicate that there is not an efficient mechanism for channelling the revenues from the tire tax into programs that effectively deal with the high cost of scrap tire management. The high cost of disposing of tires in landfills (currently $1.35 per scrap tire in the Greater Toronto Area and rising rapidly) provides an adequate financial incentive to make a number of tire recycling options economically feasible. The barrier to more recycling of scrap tires is a lack of markets for products using materials derived from scrap tires.

If OMOE wishes to influence the destination of scrap tires it must be aggressive and proactive in creating destinations of choice for scrap tires. This will likely require the use of differential subsidies that favour productive uses of tires over disposal. Subsidies should only be paid to site operators who have a credible plan for long term management of the scrap tires. In order to eliminate the need for tire dealers to charge customers a scrap tire disposal fee the least preferred, but acceptable, tire management option (likely a well-managed pile) would have to be available at zero cost to scrap tire generators. Subsidies to scrap tire processors that recycle tires or recover some of their value would have to be high enough for the processors to pay generators a fee for their scrap tires. The more-favoured the scrap tire management option, the higher the subsidy and, therefore, the fee that could be paid to scrap tire generators.

If not enough commercially-operated destinations for scrap tires can be developed, municipalities could be provided with the funds necessary to cover the costs of safely stockpiling scrap tires at municipal landfills and periodically disposing of them in the best way available at the time. In order to ensure that the tires are disposed of in an orderly fashion, the municipalities that control the tire piles could be required to issue a tender for disposal of the tires whenever a pre-determined number of tires had accumulated.

The lack of markets for products containing materials derived from scrap tires precludes a short-term recycling solution to the scrap tire problem. While a longer term recycling solution is possible, it is by no means certain. Therefore, the OMOE has the choice of encouraging less-favoured management options such as TDF and shredding and landfilling or accepting the costs and risks of storing whole tires or tire shreds for a number of year in anticipation of markets for recycled products that may never develop.

Since the major barrier to recycling of scrap tires is a lack of markets, any direct subsidies to scrap tire processors, beyond the ones described above to channel scrap tires to more-favoured uses, should be restricted to funding product and market development efforts. Differential subsidies, as discussed above, that are based on the number of tires that are received and processed should be adequate to encourage the development of sufficient processing capacity to serve the markets for products containing recycled tire materials as those markets develop.

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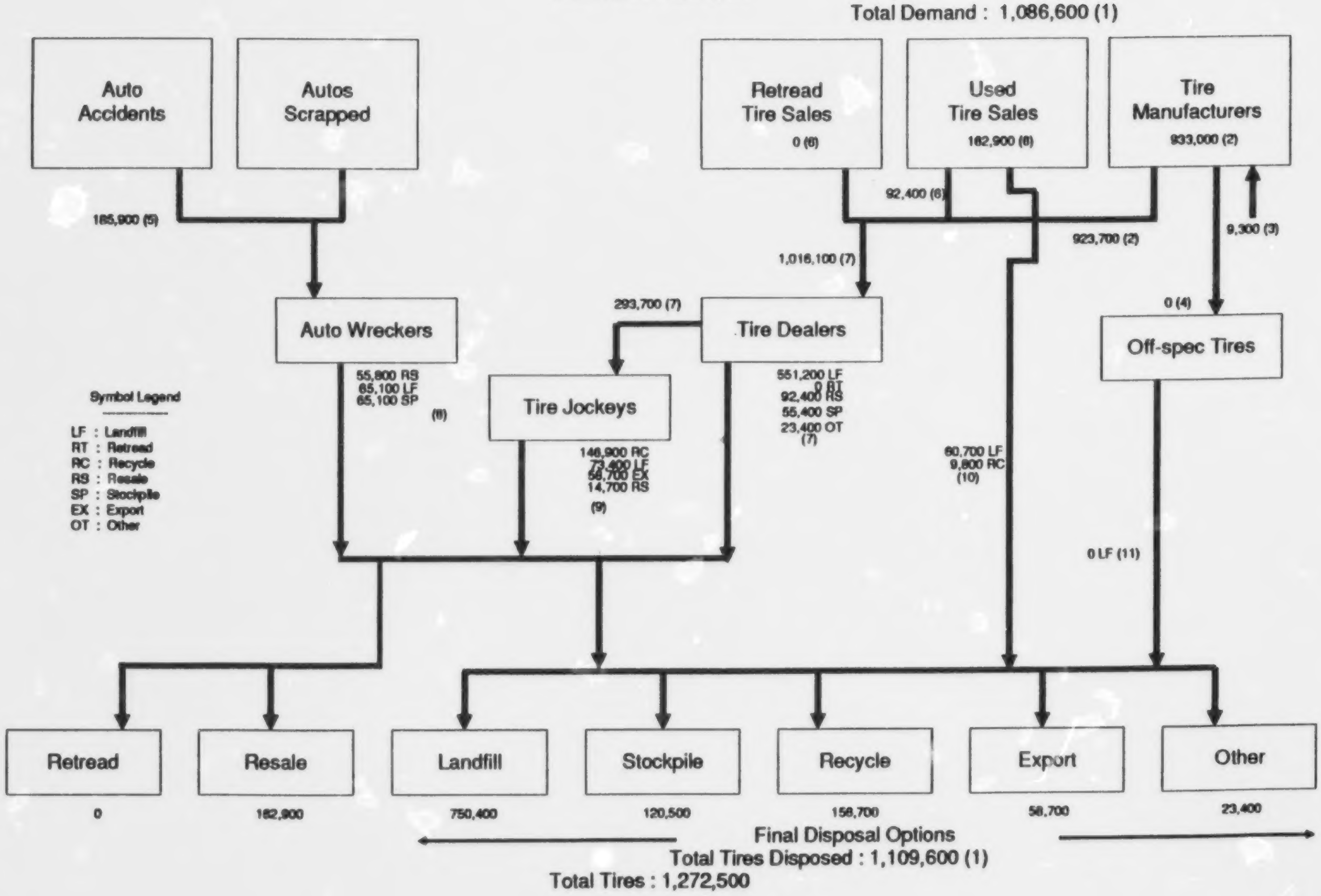
APPENDIX A

The following pages present scrap passenger tire and scrap passenger tire equivalent flow diagrams for each of the six OMOE regions. Figures 2 and 3 on pages 14 and 15 (Ontario totals) were derived from the regional breakdown in this Appendix. The *Scrap Tire Flow Net Notes* are also reproduced here for convenience.

Figure A.1

1989 Passenger Tire Flows in SW Region

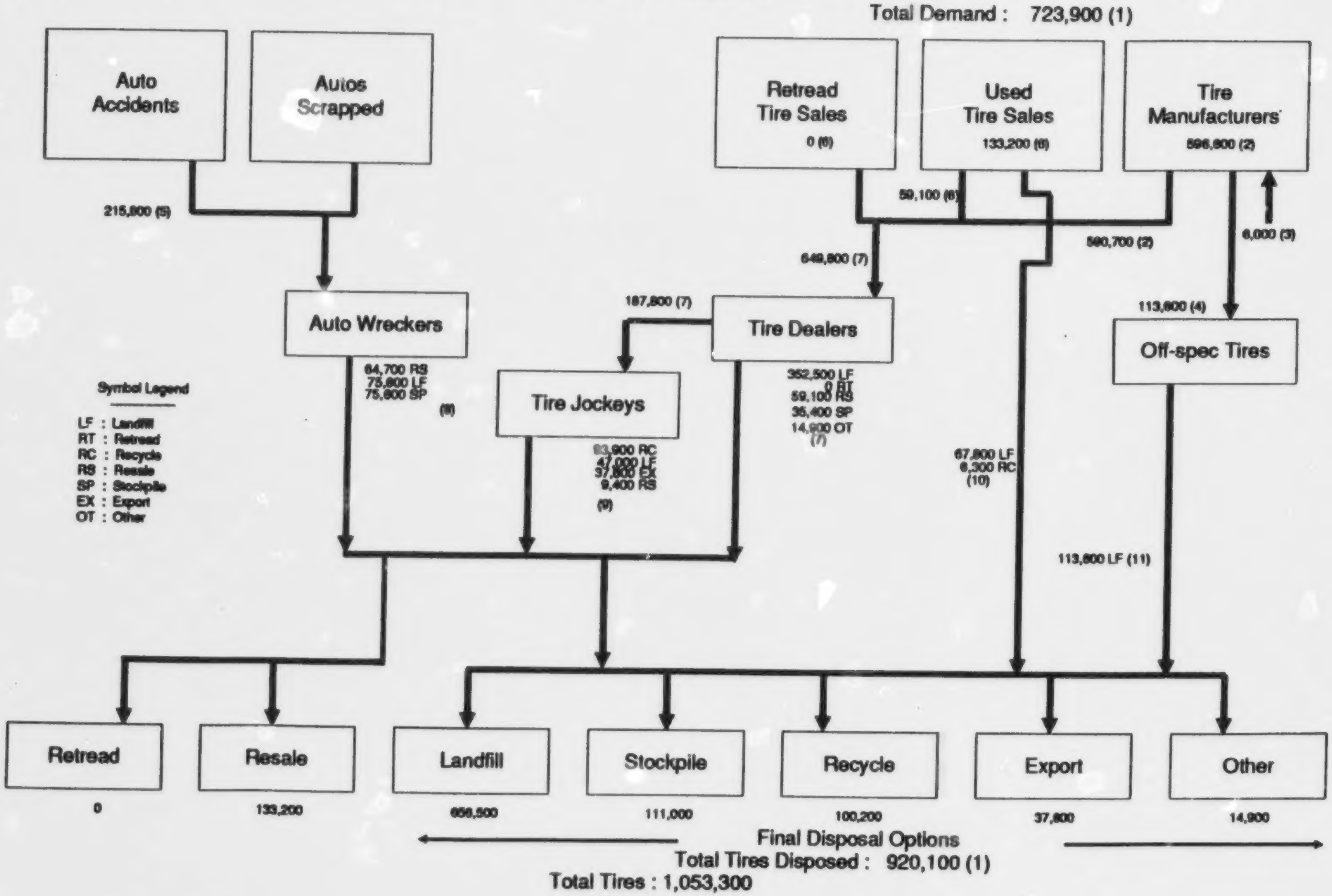
Total Tires : 1,272,500



Numbers in () refer to notes following Figures.

Figure A.2
1989 Passenger Tire Flows in WC Region

Total Tires : 1,053,300

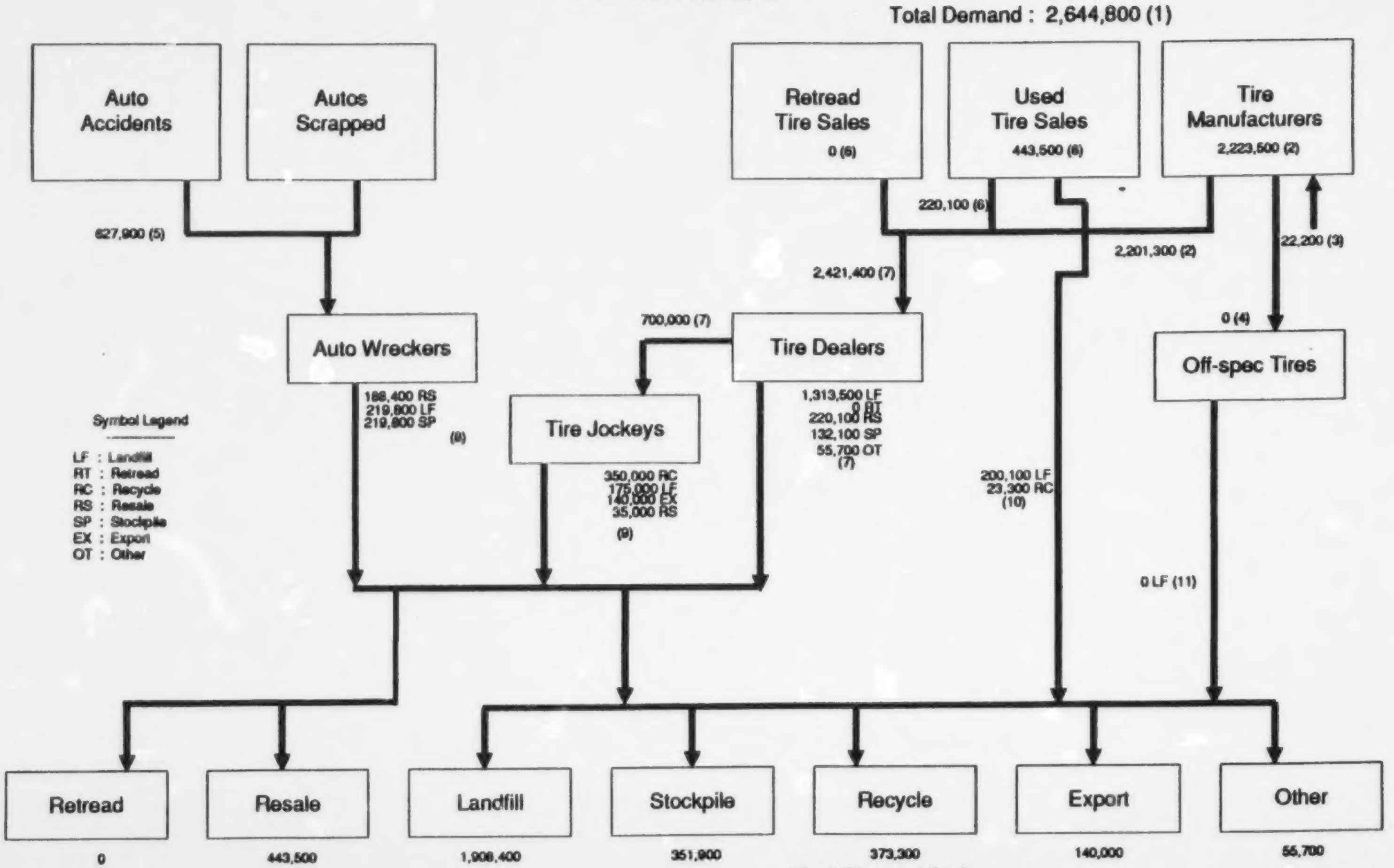


Numbers in () refer to notes following Figures.

Figure A.3

1989 Passenger Tire Flows in C Region

Total Tires : 3,272,700



Final Disposal Options

Total Tires Disposed : 2,829,200 (1)

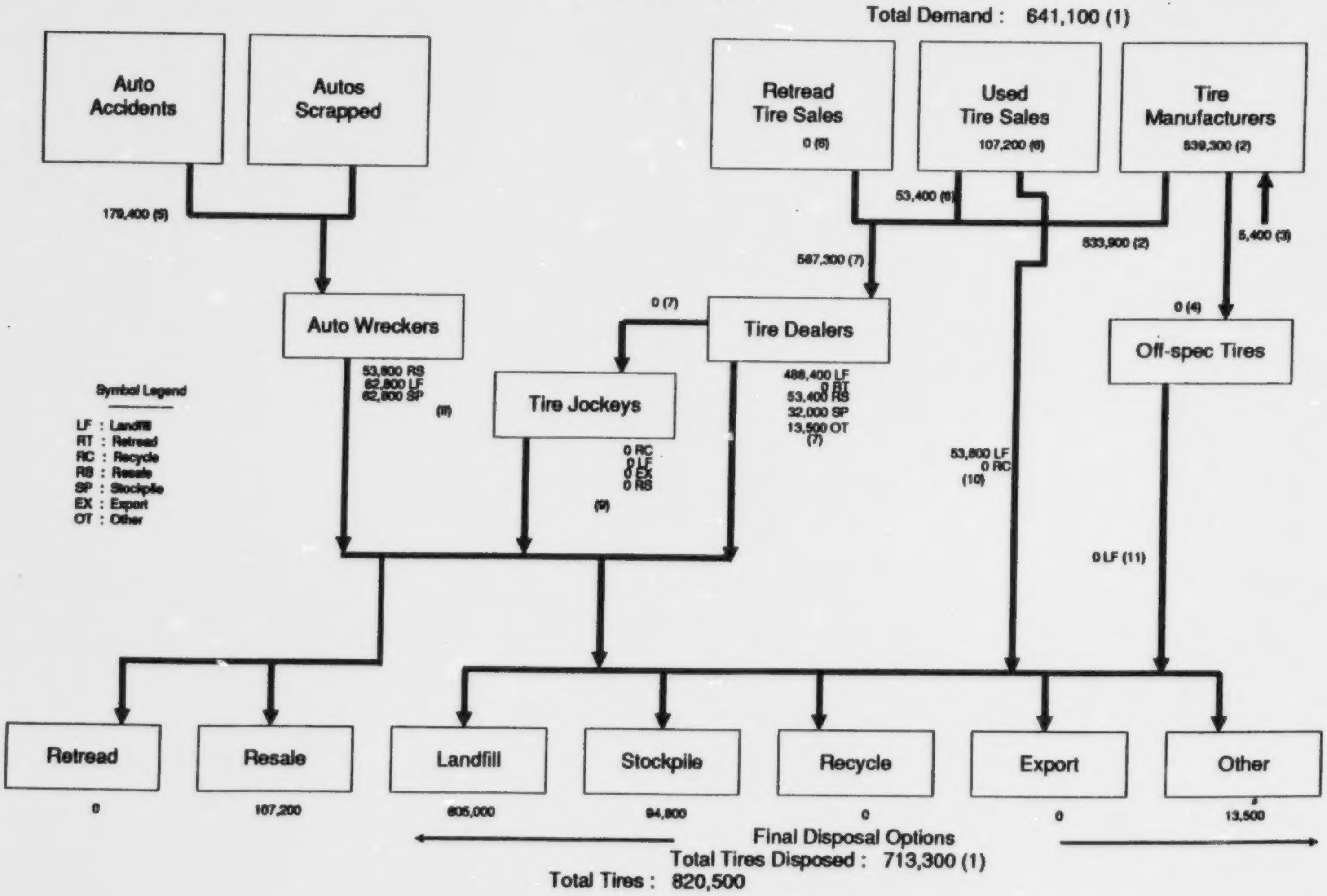
Total Tires : 3,272,700

Numbers in () refer to notes following Figures.

Figure A.4

1989 Passenger Tire Flows in SE Region

Total Tires : 820,500

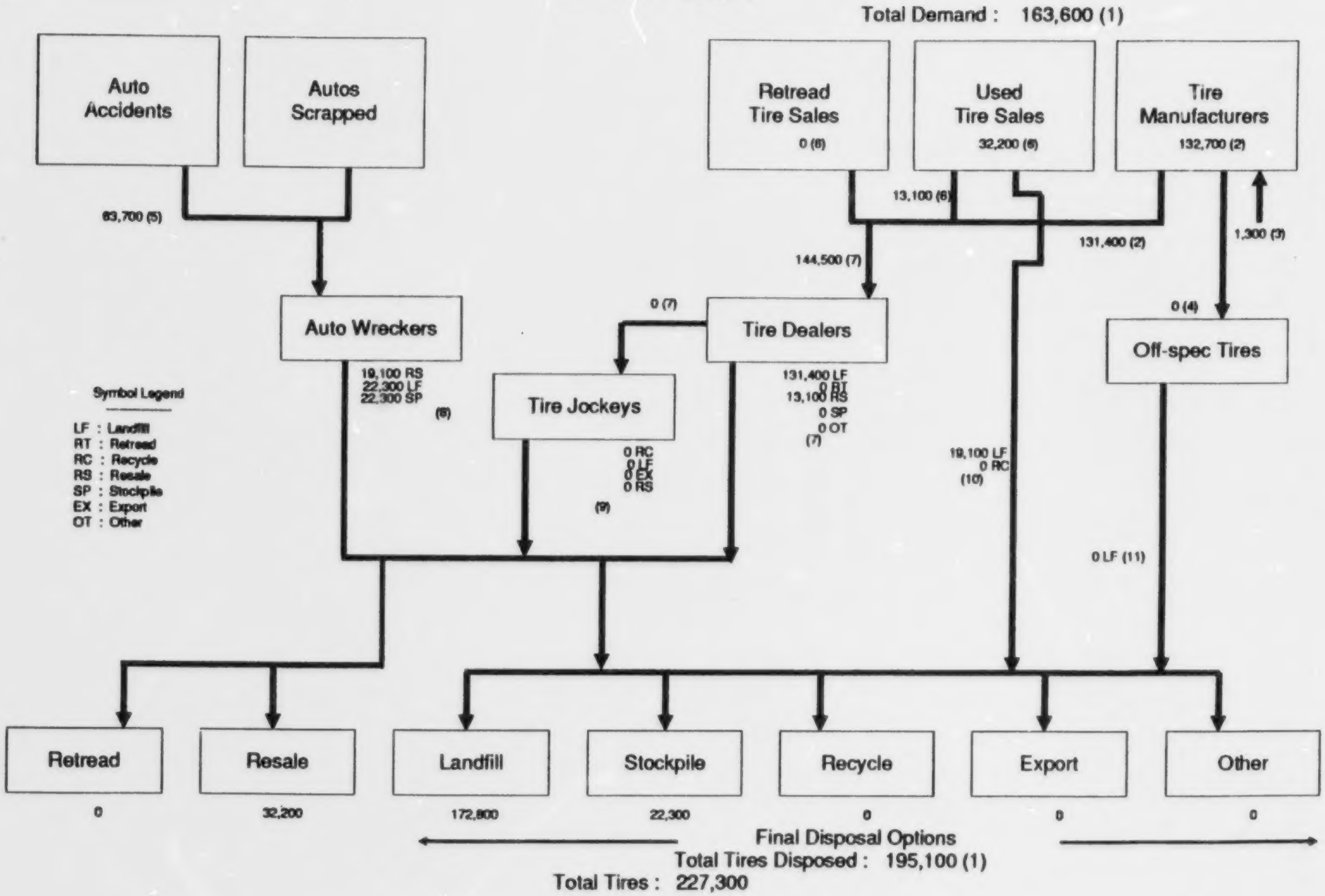


Numbers in () refer to notes following Figures.

Figure A.5

1989 Passenger Tire Flows in NE Region

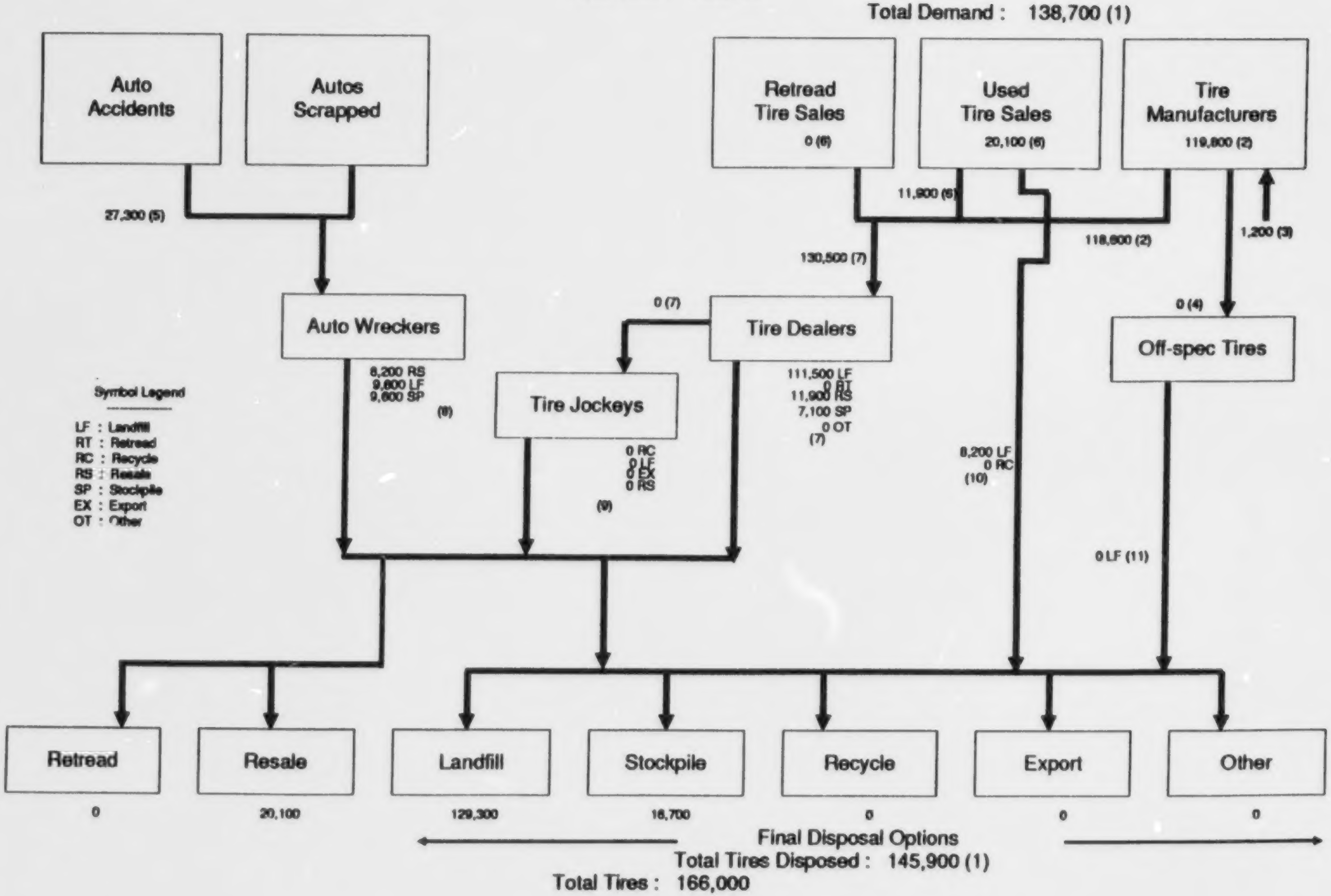
Total Tires : 227,300



Numbers in () refer to notes following Figures.

Figure A.6
1989 Passenger Tire Flows in NW Region

Total Tires : 166,000

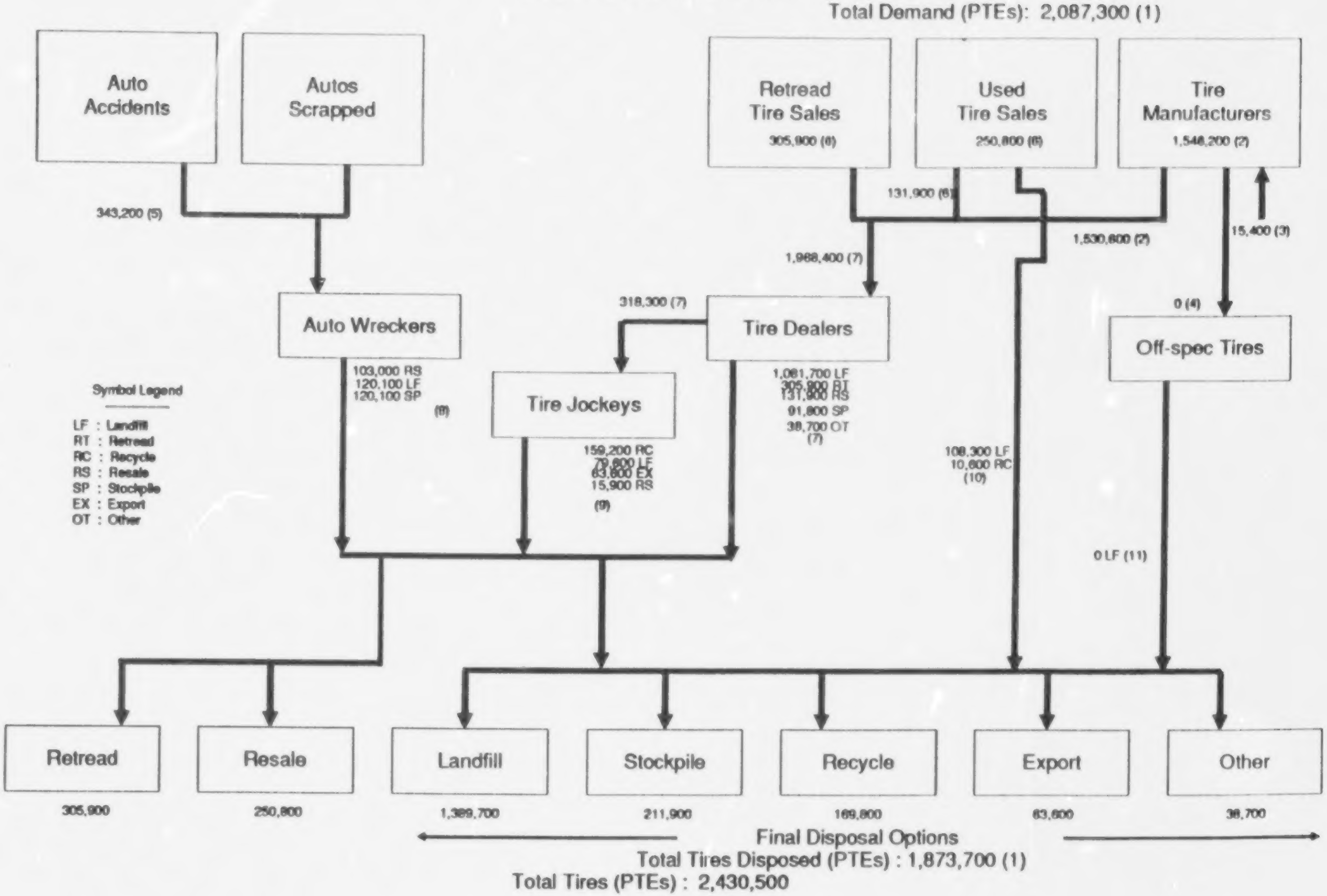


Numbers in () refer to notes following Figures.

Figure A.7

1989 Passenger Tire Equivalent Flows in SW Region

Total Tires (PTEs) : 2,430,500



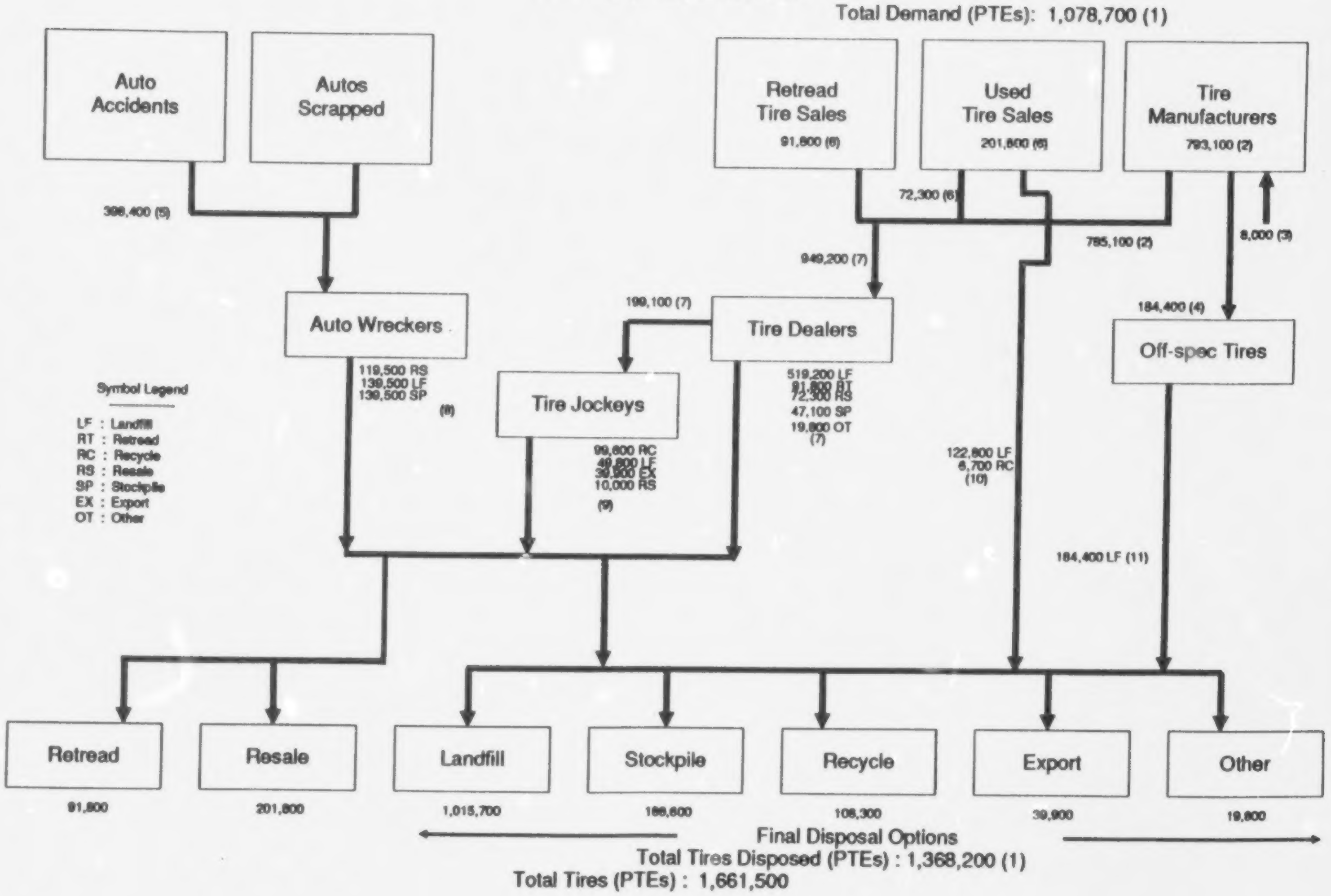
Total Tires (PTEs) : 2,430,500

Numbers in () refer to notes following Figures.

Figure A.8

1989 Passenger Tire Equivalent Flows in WC Region

Total Tires (PTEs) : 1,661,500



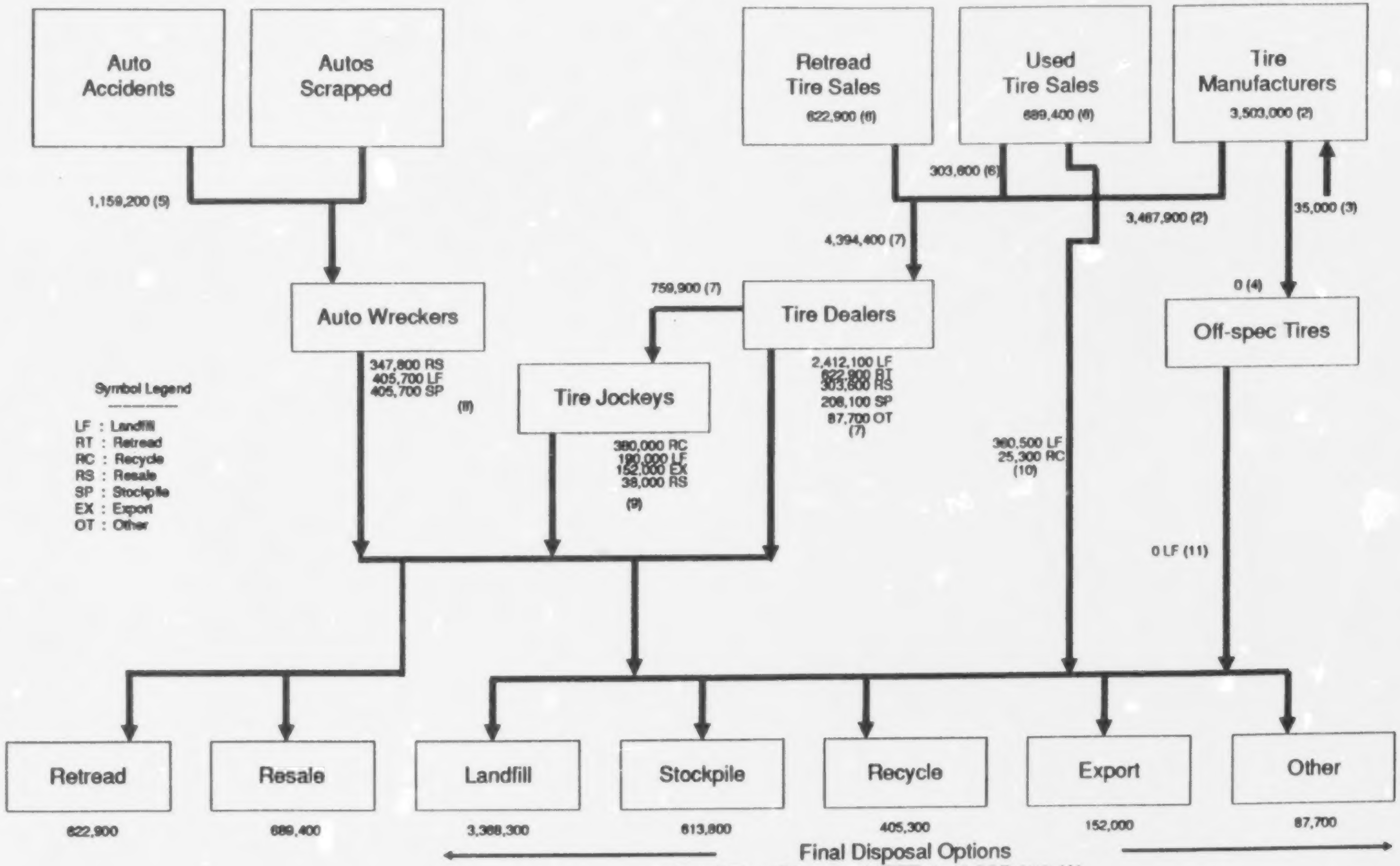
Numbers in () refer to notes following Figures.

Figure A.9

1989 Passenger Tire Equivalent Flows in C Region

Total Tires (PTEs) : 5,939,400

Total Demand (PTEs): 4,780,200 (1)



Total Tires Disposed (PTEs) : 4,627,100 (1)

Total Tires (PTEs) : 5,939,400

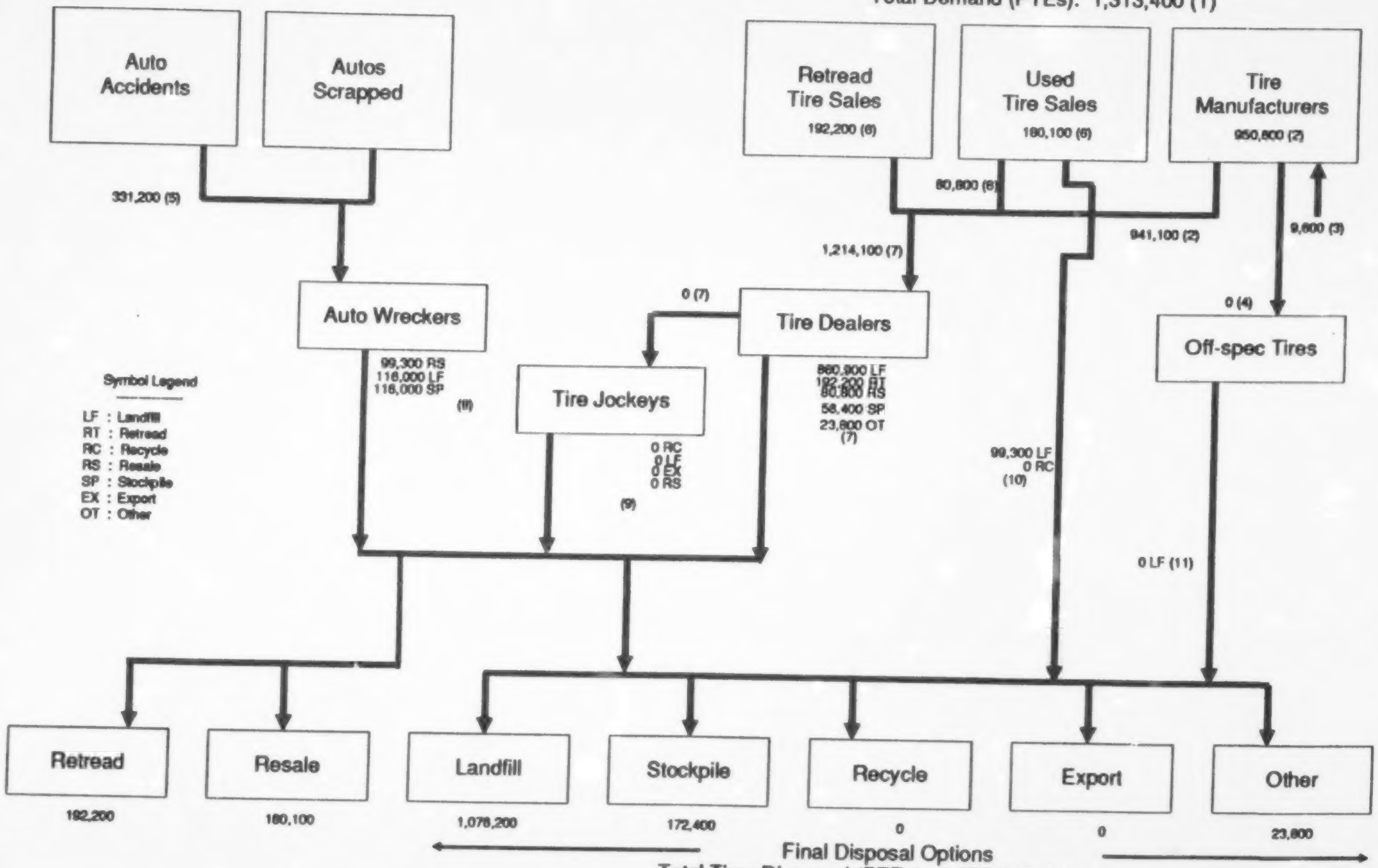
Numbers in () refer to notes following Figures.

Figure A.10

1989 Passenger Tire Equivalent Flows in SE Region

Total Tires (PTEs) : 1,664,600

Total Demand (PTEs): 1,313,400 (1)



Total Tires Disposed (PTEs) : 1,272,300 (1)

Total Tires (PTEs) : 1,664,600

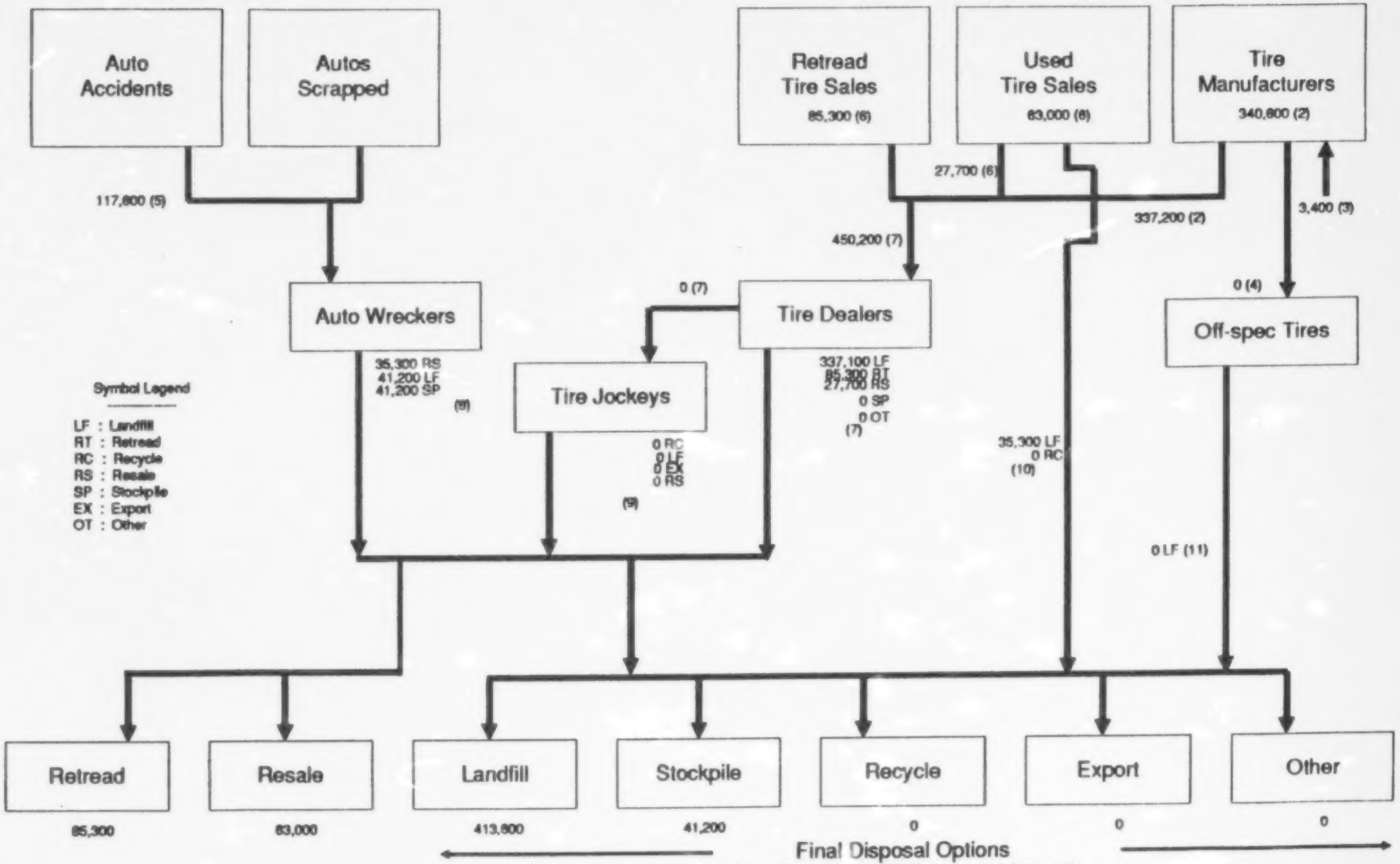
Numbers in () refer to notes following Figures.

Figure A.11

1989 Passenger Tire Equivalent Flows in NE Region

Total Tires (PTEs) : 603,100

Total Demand (PTEs): 485,500 (1)



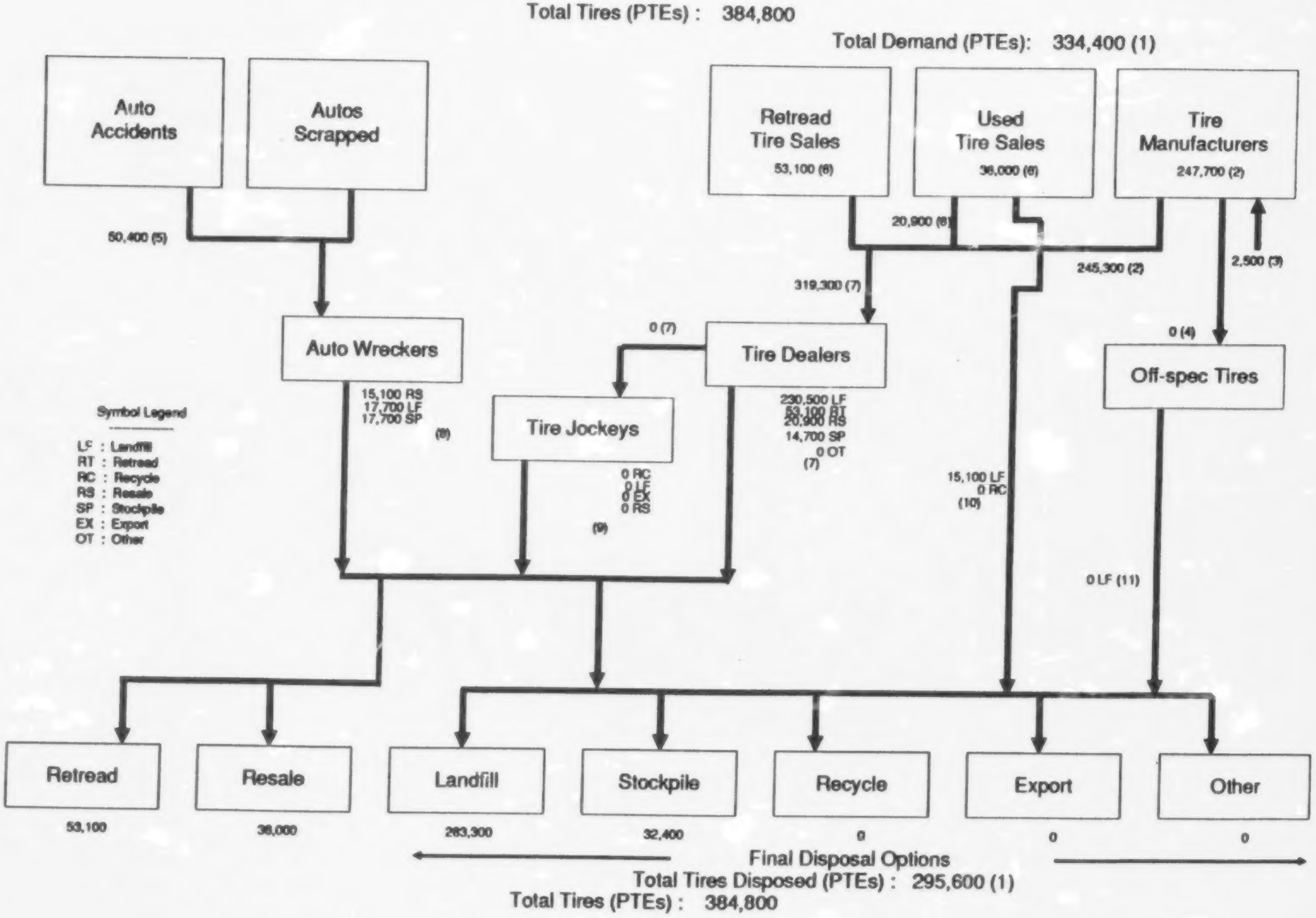
Total Tires Disposed (PTEs) : 454,700 (1)

Total Tires (PTEs) : 603,100

Numbers in () refer to notes following Figures.

Figure A.12

1989 Passenger Tire Equivalent Flows in NW Region



Numbers in () refer to notes following Figures.

Scrap Tire Flow Net Notes

1) All values are for 1989 quantities.
Total tire demand is calculated from retread, used and new tire *sales*: total tire disposal is the sum of all *final* disposal option quantities. Note that the number of tires entering the system (tire demand plus fleet scraps plus manufacturers' defects less warranty shipments) equals the number leaving (tires disposed plus retread and resale quantities).

2) Source: Rubber Association of Canada (R.A.C.), 08 May 1990, page 3 (personal communication):
The total number of tires shipped from manufacturers was cross-checked with published Statistics Canada figures for Canada. Regional quantities are prorated by Ontario automobile registration statistics, as published by Statistics Canada (auto registration weights are nearly identical to sales by region as reported by the manufacturers).

3) Conversations with tire distributors, manufacturers, and large dealers indicate that warranty replacements represent not more than 1 percent of sales. Since the shipment figures obtained from manufacturers were known to include warranty replacements subtracting 1 percent yields the net quantity shipped to dealers and avoids double-counting.

4) The defect rate of tire manufacturing plants in the West-Central region was estimated to be on the order of 2 or 3 percent of output (2.5 percent of shipments is used). All of these tires are assumed to be disposed of in the West-Central region.

5) Source: R.A.C., 08 May 1990, page 2 (personal communication):
Calculations by R.A.C. show the difference in annual auto registration versus new car sales. The difference is the number of vehicles taken out of service (sent to auto wreckers) in a year. This number includes those autos that are damaged beyond repair in accidents plus those scrapped through "old age".

The values calculated by R.A.C. are for 1988, however as tire sales have declined or stayed the same over the last two years, the figure is probably conservative.

Five tires per vehicle is assumed, with only light truck and passenger tires included, since conversations with individual auto wreckers and the Auto Wreckers Association of Ontario suggest that heavy trucks and industrial vehicles are not received by auto wreckers. The provincial total is prorated regionally by auto registration statistics.

Total tires "generated" by auto wreckers:

Total Passenger Tires:	1,328,980	(use 1.3 million)
Total Light Truck Tires:	719,665	
Total Tires	2,048,645	(use 2.0 million)
Total Passenger Tire Equivalents	2,396,615	(use 2.4 million)

See Note #13 for overall checks using these numbers and published tire shipment numbers.

6) Retread and Used Tire Sales figures are calculated from other data. Input and output quantities are the sum of all actions resulting in resale or retread. For example, Auto Wreckers, Tire Dealers, and Tire Jockeys all report sales of used tires; the total quantity of used tires sold is calculated as the sum of 720,100 (Auto Wreckers), 637,200 (Dealers) and 63,900 (Jockeys).

It was not possible to cross-check the used tire sales figures with another source. However, conversations with *Bandag Canada Limited* suggested that the total retread of heavy tires in Ontario is on the order of 300,000 tires virtually all of which are heavy truck tires. The figure shown of 1,351,200 retreaded passenger tire equivalents equates to about 260,000 heavy vehicle tires.

Figures from the U.S. Tire Retread Information Bureau indicate that retreaded passenger tire sales (from all sources) are about 10 percent of *new* passenger tire sales. Ontario tire dealers reported negligible light vehicle tire retread rates while tire jockeys claim about a 10 percent retread rate. However, all retreads by jockeys are actually exported and are not part of the Ontario demand for light vehicle tires.

7) Source: Tire Dealer Survey Summary
Due to the relatively small sample size per region, larger region areas were averaged in some cases. The disposal method estimates for the province are shown in Table A.1 below.

See also Note #12 for a discussion of retreaded tire figures.

Table A.1 - Disposal Methods Employed by Ontario Tire Dealers
(average for the sample)

Disposal Method	Landfill	Retread	Tire Jockey	Resale	Stockpile	Other
Percentage	59%	15%	14%	7%	4%	2%

8) Source: Stockpiler Survey Summary
Auto wreckers consistently reported about a 30% resale rate. This was confirmed by the Auto Wreckers Association of Ontario. The high resale rate is probably due to the number of vehicles scrapped in "fatal" auto accidents where the car may be wrecked, but the tires often remain serviceable. Auto wreckers claimed a high percentage of vehicles brought in by insurance companies. Auto Wreckers tended to stockpile half, and landfill half of all tires not suitable for resale. This ratio was also supported by the Association.

Very few auto wreckers interviewed had dealings with tire jockeys. Consequently, the number of tires transmitted through this route was assumed to be negligible (see below).

9) Source: Tire Jockey Survey Summary
No Tire Jockeys were identified in the South East, North East and North West regions. This was confirmed by tire dealers in the respective areas who indicated that they do not use tire jockeys. Dealers in all other areas reported using jockeys to some degree (see Note #7). The figure of about 1.3 million tires sent to Tire Jockeys derived from the Dealer Survey agrees well with figures provided by interviewed Tire Jockeys.

The following disposal options were calculated from data collected in the tire jockey survey, and assumed for all regions using their services (ie. South West, West Central, and Central Regions):

Landfill	Stockpile	Recycle	Export	Retread	Resale
25%	0%	50%	10%	10%	5%

All those interviewed maintained that almost no heavy vehicle tires were handled by tire jockeys. This was confirmed by tire dealers, and is reflected in the tables.

The number of tires collected from auto wreckers is also negligible, as virtually all tires accepted by jockeys originate from tire dealers. This was also confirmed by auto wreckers.

Tire jockeys employ a variety of recycling methods. Some are recycled on-site by the jockeys themselves (mainly the stamping of bias ply tires), however the majority are sent to one of the operating tire recyclers (see Recycling on page 21). Assuming a 50 percent recycle rate for *all* tire jockeys is probably liberal. It results in a total recycling quantity for the province of almost 700,000 tires, which is very near to the entire recycling capacity presently available in the province.

10) Retread/Resale tire final destination figures are based on the following assumptions:
- retreads/resales result in 100 percent scrap. ie. the replaced tire cannot be reused or retreaded; it may be recycled however, and note that:
- tire jockeys recycle twice as many tires as they landfill (see Note #9);
- All other sources of retread/resale tires landfill all tires replaced by the process.

11) Some landfills reported accepting off-spec tires from manufacturers. Consequently, all tires that the manufacturer scraps were assumed to be landfilled.

12) With Respect to Total Scrap Tire Generation:
The following calculations examine the total scrap passenger tire flow, and are used as a check of the rates derived. As can be noted, the results are highly consistent with the rates used in Figures 2 and 3.

Demand Side

New Vehicle Sales	660,000[22]
Increase in Registration	-235,000
----------------------------	-----------
Vehicles Removed per Year	425,000

Replacement Rate = (Vehicles Removed)/(Vehicles Registered)
= 425,000/4,500,000
= 8 to 10% per year
Average Auto Life = 1/(Replacement Rate)
= 1/(8 to 10% per year)
= 10 to 12 years

Assuming 2 or 3 tire replacements per auto lifetime,
Total Number of Tires Replaced per Year
= (Vehicles Registered)*(Number of Tire Replacements)*(5 Tires per Replacement)/(Average Auto Life)
= 6 to 8 million tires per year.

Supply Side

Total New Tires Shipped	4.5 million	
Used Tire Sales	1.3 million	(calculated)
------------------------------	-------------	
Total Tires Sold	5.8 million	

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[22] This calculation assumes that every new car sold is registered in the province. The change in vehicle registrations therefore, reflects the difference between new vehicle sales and the removal of older cars from the fleet.

APPENDIX B

STOCKPILES IN ONTARIO

		Tire Inventory				Type Of Tire (%) (Charge is paid TO company)							
						Passenger		Light Truck		Heavy Truck		Other	
City	Bus. Type	Received per Year	Presently On Site	Pass. Equiv.	OMOE Estimate	%	Charge	%	Charge	%	Charge	%	Charge
SOUTHWEST REGION													
Exeter	TD	2 400	4 500	15 912	40 000	35		20		25		20	
Proton	AW	1 600	25 000	45 200	25 000	75		10		10		5	
Kamoka	AW	N/A	6 000 *	6 058	6 000	98		2					
Mildmay	AW	480	200 000	220 000	200 000	98				3			
London	AW	55 000	2 000	2 000	2 000	100							
WEST-CENTRAL REGION													
Welland	RC	0	20 000	56 317	46 000	51	$0.78	14	$0.78	24	$3.50	11	$3.50
Pt. Colbourne	RC	0	375 000	1 055 940	550 000	51	$0.78	14	$0.78	24	$3.50	11	$3.50
Mt. Hope	SP	32 400	1 000 000	4 600 000	800 000	10	$1.00			90	$4.00		
Orangeville	RC	300 000	6 000	6 000	7 000	100	$0.63						
Port Ryerse	FF	0	20 000	89 888	100 000	30				48		22	
Fort Erie	AW	60 000	32 500	71 500	30 000	70	$0.82			30	$4.10		
Hagersville	SP	N/A	70 000 *	N/A	70 000								
Vittoria	FF	N/A	30 000	37 920	50 000	95				3		2	
Simcoe	FF	N/A	10 000	N/A	100 000								
Cambridge	LF	164 835	37 500				$1.50						
Niagara Falls	LF	52 747					$1.36						
St. Catherines	LF												

*Owner could not estimate the number of tires presently on site. The OMOE estimate is used instead

TJ - tire jockey AW - auto wrecker RC - recycler SP - speculator LF - landfill TD - tire dealer FF - farmer

STOCKPILES IN ONTARIO

		Source Of Tires						Destination/Use (Fee is paid TO company)								
	Bus.	Primary		Secondary		Other		Primary			Secondary			Other		
City	Type	Method	%	Method	%	Method	%	Use	%	Fees	Use	%	Fees	Use	%	Fees
SOUTHWEST REGION																
Exeter	TD	DL	100					SP	100							
Proton	AW	IN	100					SP	100							
Kamoka	AW	DL	30	IN	60	TC	10	SP	100							
Mildmay	AW	IN	100					SP	95		RU	5	20.00			
London	AW	TC	100					RU	90	22.50	LF	10				
WEST-CENTRAL REGION																
Welland	RC	DL	100					RC	90		RU/E	5		RT	5	
Pt. Colbourne	RC	DL	100					RC	90		RU/E	5		RT	5	
Mt. Hope	SP	DL	70	AW	30			SP	64		RT	36	2.00	RC	0	-0.60
Orangeville	RC	TJ	99	SS	1			RC	100							
Port Ryerse	FF	DL	100					FF	100	0.00						
Fort Erie	AW	SS	80	DL	20			SP	100							
Hagersville	SP															
Vittoria	FF	DL	100					FF	100							
Simcoe	FF	DL	100					SP	100							
Cambridge	LF	TM	60	DC	20	DL	20	SP	100							
Niagara Falls	LF	DL	100					LF	100							
St. Catherines	LF															

*Owner could not estimate the number of tires presently on site. The OMOE estimate is used instead

TJ - tire jockey AW - auto wrecker RC - recycler SP - speculator LF - landfill TD - tire dealer FF - farmer

STOCKPILES IN ONTARIO

		Tire Inventory				Type Of Tire (%) (Charge is paid TO company)							
						Passenger		Light Truck		Heavy Truck		Other	
City	Bus. Type	Received per Year	Presently On Site	Pass. Equiv.	OMOE Estimate	%	Charge	%	Charge	%	Charge	%	Charge
CENTRAL REGION													
Toronto	TJ	424 615	341 538 *	1 468 069	341 538	41	$0.85		$2.00	31	$8.00	29	
Whitby	AW	20 000	500 000	540 800	250 000	97		2				1	$0.00
Barrie	AW	10 500	3 500	3 500	15 000	100							
Port Hope	AW	3 000	5 000	5 648	51 383	95		2		3			
Scarborough	RC	periodic shipments	5 000	7 000	38 300	90	$0.80			10			
Toronto	AW	25 000	5 500	5 632	7 000	95	$0.00	5	$0.00	0		0	
Bowmanville	AW	10 000	10 000	10 240	20 000	95		5					
Lindsay	AW	2 500	112 900	112 900	112 900	100							
Brampton	TJ	250 000	10 000	10 240	10 000	95	$1.10	5	$1.10				
Sutton West	AW	25 000	50 000	70 000	60 000	90				10			
Toronto	RC	periodic shipments	60 000	60 000	100 000	100							
Kendall	SP	N/A	250 000 *	0	250 000								
Ayr	RC	0	75 000 *	0	75 000								
Toronto	AW	24 000	5 000 *	5 720	5 000	98						2	
Utopia	AW	3 000	8 000	8 077	11 350	98		2					
Brampton	LF						$0.82						
Keele Valley	LF						$0.77						
Tiny Twp.	LF	3 500					$1.25						
Northumberland	LF	6 600					$0.38						
Orono	LF	109 890					$1.00						
Peterborough	LF	6 600					$0.68						
Bridgenorth	LF	105					$0.00						
Lindsay	LF	7 500	25 000				$3.00						
SOUTHEASTERN REGION													
Carlsbad Springs	AW	4 000	35 000	35 000	50 000	100							
Glenburnie	AW	3 000	2 000	2 000	20 000	100							
Orleans	AW	10 000	15 000	15 360	16 000	95		5					
Amprior	AW	5 400	65 000	119 080	60 000	83				12		5	
Ashton	AW	2 000	80 000 *	183 680	80 000	65		10		17		8	
Orleans	AW	1 800	8 000	11 584	26 000	80		10		10			
Cornwall	LF	1 650					$0.27						
Ottawa	LF	50 000	20 000				$0.39						
Ottawa	LF	35 000					$5.00				$15.00		

*Owner could not estimate the number of tires presently on site. The OMOE estimate is used instead

TJ - tire jockey AW - auto wrecker RC - recycler SP - speculator LF - landfill TD - tire dealer FF - farmer

STOCKPILES IN ONTARIO

		Source Of Tires						Destination/Use (Fee is paid TO company)								
	Bus.	Primary		Secondary		Other		Primary			Secondary			Other		
City	Type	Method	%	Method	%	Method	%	Use	%	Fees	Use	%	Fees	Use	%	Fees
CENTRAL REGION																
Toronto	TJ	RC	39	RU	20											
Whitby	AW	TC	75	IN	25			SP	100							
Barrie	AW	IN	80	TC	20			SP	93		RU	8	12.50			
Port Hope	AW	TC	50	IN	50			RU	60	42.50	XX	20	0.00	SP	20	
Scarborough	RC	DL	85	TJ	15			RC	100							
Toronto	AW	ID	60	DL	40			SP	52		TJ	48				
Bowmanville	AW	TC	80	IN	20			RU	40	25.00	EX	35		SP	25	
Lindsay	AW	TC	100					SP	63		RU	38	25.00			
Brampton	TJ	DL	100					LF	38	-0.83	RC	30	-0.45	RT	20	2.00
Sutton West	AW	AW	70	IN	30			SP	87		RT	12		RU	1	0.00
Toronto	RC	TJ	100					RC	100							
Kendall	SP															
Ayr	RC															
Toronto	AW	IN		TC				TJ	100	0.00						
Utopia	AW	IN	100					SP	95		LF	5				
Brampton	LF							LF	100							
Keele Valley	LF															
Tiny Twp.	LF	DL	60	IN	40			TJ	100							
Northumberland	LF	DL	60	IN	35	TC	5	LF	100							
Orono	LF	TM		DL				LF	100							
Peterborough	LF	DL	60	IN	35	TC	5	LF	100							
Bridgenorth	LF	SS	75	IN	25			LF	-257		RU	357				
Lindsay	LF	DL	80	IN	15	SS	5	RE	100							
SOUTHEASTERN REGION																
Carlsbad Springs	AW	TC	50	IN	50			SP	75		RU	25	27.50			
Glenburnie	AW	TC	48	IN	32	DL	20	RU	75	25.00	SP	25				
Orleans	AW	TC	100					RU	60	25.00	SP	40				
Arnprior	AW	IN	100					SP	80		RU	20	30.00			
Ashton	AW	DL	75	AW	25			SP	70		RU	30	20.00			
Orleans	AW	IN	100					SP	67		RU	33	10.00			
Cornwall	LF	DL	60	IN	35	TC	5	LF	100							
Ottawa	LF	DL	80	IN	20			LF	60		SP	40				
Ottawa	LF	MW	100					LF	100							

*Owner could not estimate the number of tires presently on site. The OMOE estimate is used instead

TJ - tire jockey AW - auto wrecker RC - recycler SP - speculator LF - landfill TD - tire dealer FF - farmer

STOCKPILES IN ONTARIO

		Tire Inventory				Type Of Tire (%) (Charge is paid TO company)							
						Passenger		Light Truck		Heavy Truck		Other	
City	Bus. Type	Received per Year	Presently On Site	Pass. Equiv.	OMOE Estimate	%	Charge	%	Charge	%	Charge	%	Charge
NORTHEASTERN REGION													
Garson	AW	5 000	7 000	7 336	10 000	90		10					
Strugeon Falls	RC	300 000	8 000	8 000	5 000	100	$0.50						
Sudbury	AW	1 500	9 000	9 043	9 000	99		1					
Hamner	AW	600	3 500	3 517	4 000	99		1					
New Liskeard	LF						$0.00						
Sault Ste. Marie	LF	9 000					$0.09						
NORTHWESTERN REGION													
Thunder Bay	SP	3 000	17 500	58 800	50 000	45				50		5	
Dryden	LF						$0.00						
Fort Frances	LF	500	2 500				$0.00						
Thunder Bay	LF	137 363					$0.14						
TOTALS (STOCKPILES ONLY)													
Southwest		59 480	237 500	289 170	273 000								
Westcentral		392 400	1 563 500	5 917 565	1 753 000								
Central		797 615	1 441 438	2 307 826	1 347 471								
Southeastern		26 200	205 000	366 704	252 000								
Northeastern		307 100	27 500	27 896	28 000								
Northwestern		3 000	17 500	58 800	50 000								
TOTAL		1 585 795	3 492 438	8 967 960	3 703 471								

TJ - tire jockey AW - auto wreck er RC - recycler SP - speculator LF - landfill TD - tire dealer FF - farmer

STOCKPILES IN ONTARIO

		Source Of Tires						Destination/Use (Fee is paid TO company)								
	Bus.	Primary		Secondary		Other		Primary			Secondary			Other		
City	Type	Method	%	Method	%	Method	%	Use	%	Fees	Use	%	Fees	Use	%	Fees
Garson	AW	TC	100					LF	90	-1.30	RU	10	42.50			
Strugeon Falls	RC	TJ	100					RC	100							
Sudbury	AW	IN	100					SP	100							
Hamner	AW	TC	90	IN	10			SP	67		RT	33	5.00			
New Liskeard	LF	DL	90	SS	10			LF	100							
Sault Ste. Marie	LF	DL	100					SP	100							
NORTHWESTERN REGION																
Thunder Bay	SP	DL	50	SS	50											
Dryden	LF	DL	80	IN	20			SP	99		RE	1				
Fort Frances	LF	DL	50	IN	25	TC	25	SP	98		RE	2				
Thunder Bay	LF	DL	75	IN	25			LF	100							

*Owner could not estimate the number of tires presently on site. The OMOE estimate is used instead

TJ - tire jockey AW - auto wrecker RC - recycler SP - speculator LF - landfill TD - tire dealer FF - farmer